JUN 1 1949

JOURNAL OF MAMMALOGY

VOL. 30 MAY 1949 NO. 2

AMERICAN SOCIETY OF MAMMALOGISTS

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Journal of Mammalogy is published quarterly by the American Society of Mammalogists, Mt. Royal and Guilford Aves., Baltimore 2, Md. Entered as second class matter, November 22, 1919, at the Postoffice, Baltimore, Md., under the act of March 3, 1879.

Made in United States of America

JOURNAL OF MAMMALOGY

Published Quarterly by the American Society of Mammalogists

VOL. 30 MAY —, 1949 No. 2

THE BACULA OF SOME NORTH AMERICAN VESPERTILIONID BATS

BY W. J. HAMILTON, JR.

Increasing interest in the baculum or os penis of mammals as an aid to classification has been evident in recent years. The studies of Burt (1936), Wade and Gilbert (1940), Didier (1943), and Hamilton (1946) have indicated that this structure may be of some value in defining relationships. Howell (1938), after examining the bacula of subgeneric groups of ground squirrels, suggested that this bone has characters that are of assistance in defining the groups. He did not believe that, in the absence of trenchant cranial characters, the morphology of the baculum alone should be considered of generic value.

It has long been known that most genera of bats possess a baculum. Early investigators of this structure in the Chiroptera include Robin (1881), Gilbert (1892), Gerhardt (1905), and Chaine (1926). Pohl (1928) considered the relation of the baculum to the rest of the penis essential in determining relationships, a tenet in which Davis (1947) concurs. Davis further suggests the value of a study of the penis proper, especially the caput penis, as a possible aid in determining relationships. Robin (*op. cit.*) observed that in the absence of a chiropteran os penis, a histological trace was present. Ercolani (1868) likewise found a rudimentary penis bone in *Vespertilio murinus*.

The penis bone of vespertilionid bats studied by the writer is normally situated in the glans above the urethra. In some genera it may cap the entire glans, or it may be reduced to a vestige, directed dorsally from the tip of the glans. Ercolani (*op. cit.*), Disselhorst (1897), and Gilbert (*op. cit.*) state that the penis of bats lacks a prepuce; one may readily find this structure in fresh specimens. It is easily overlooked in bats which have long been preserved.

Gilbert (*op. cit.*) figures a sagittal view of the os penis of *Vespertilio murinus*, indicating that the bone arises from the distal tip of the corpus fibrosum and is surrounded by the glans penis. Mathews (1937) discusses the form of the penis in some rhinolophids and vespertilionids, figuring the relation of the baculum to other parts of the penis. In stereograms of the penis in *Myotis*, *Pipistrellus*, and *Plecotus*, the baculum saddles the urethra, its proximal part being imbedded in the corpus cavernosum while the distal portion extends into the glans. A similar situation prevails among American vespertilionids; the size of the bone determining its position in relation to these parts. In *Myotis*, the bone is situ-

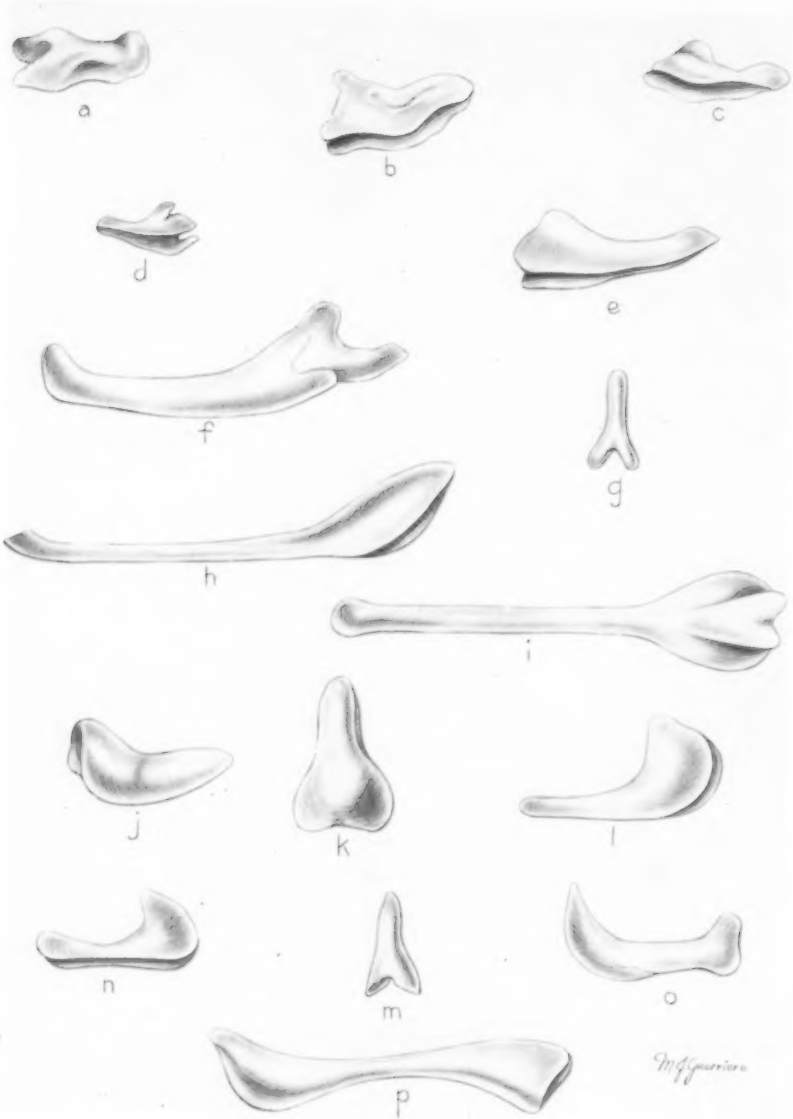

PLATE I

Baculа of some vespertilionid bats: a, *Myotis lucifugus;* b, *Myotis grisescens;* c, *Myotis keenii septentrionalis;* d, *Myotis subulatus leibii;* e, *Pizonyx vivesi;* f, *Pipistrellus hesperus;* g, *Pipistrellus subflavus obscurus;* h, *Lasionycteris noctivagans;* i, *Lasionycteris noctivagans,* dorsal view of different specimen; j, *Corynorhinus macrotis,* lateral aspect; k, *Corynorhinus macrotis,* dorsal aspect; l, *Dasypterus floridanus;* m, *Eptesicus fuscus;* n, *Lasiurus borealis;* o, *Lasiurus cinerus;* p, *Nycticeius humeralis.* All figures indicate lateral aspects except g, i, k, and m, which are dorsal. × 25.

ated in the glans, whereas in *Pipistrellus hesperus* and *Lasionycteris* it extends well into the corpus cavernosum.

MATERIAL AND METHODS

All specimens examined have been adult, as determined by examination of the metacarpals and skull. Most of the material was obtained from fresh specimens. For alcoholic specimens of *Pizonyx*, I am indebted to Dr. Remington Kellogg and Dr. Seth Benson. E. W. Jameson, Jr. provided several specimens.

Clearing of the penis in NaOH and staining in alizarin has been described elsewhere (Hamilton, 1946). Since the os penis of some bats is little more than a spicule of bone, great care must be exercised in clearing. Several specimens were lost, or the identity destroyed, by keeping the bone too long in sodium hydroxide. Fresh specimens clear much more rapidly than preserved material. A one per cent solution is satisfactory, the specimen being removed after ten hours for examination and returned to the solution if additional clearance is needed. The relation of the bone to other parts of the penis is evident in specimens so cleared. After cleaning, the bones are placed in 70 per cent alcohol. Miss Mary Guerriere made the illustrations under my supervision.

DESCRIPTIONS OF BACULA

Myotis l. lucifugus.—The os penis is best described as a little saddle. Dorsally, the distal extremity forms a little knob. A narrow median ridge extends ventrally, concave on the sides and flaring out ventrally. The proximal portion is formed of two extensions, or "runners." Ventrally, the bone is deeply concave, the whole structure thus appearing as a thin investure over the dorsal wall of the urethra. The bone has a length of 1 mm. (Pl. I, a).

Myotis subulatus leibii.—This, the smallest species of the genus, has a tiny deeply sculptured baculum. The slender distal part terminates in a slight knob. Proximally, the dorsal and lateral extensions are separated by a prominent notch. Ventrally, the bone is deeply concave. The bone has a length of .7 mm. (Pl. I, d).

Myotis griscesens.—In dorsal aspect, the bone is broadly convex, without a prominent median ridge. The distal extremity may have a very slight protuberance or slight knob in median aspect; this swelling is lacking in most specimens. Proximally, the dorsum forms a little knob, ventrally the lateral ends flare slightly from the middle. Ventrally, the bone forms a broad flat base, the lateral margins deflected sharply downward and terminating at their greatest depth in the ill-defined proximal spurs (Pl. I, b).

Myotis keenii septentrionalis.—The baculum of this species differs little from that of *lucifugus*. In lateral aspect, it is characterized by a high proximal portion which turns at a 45° slope to the middle portion, then extends as a straight spicule that expands into a bulbous tip. Ventrally, a similar concavity exists, although in one specimen the two lateral basal wings meet across the base, lending the appearance of solidity. The bone is .8 mm. long (Pl. I, c).

Pizonyx vivesi.—In general aspect the baculum of this genus is not unlike that of *Myotis* although it lacks the saddle-like appearance. The distal end tapers to a flattened, slightly elevated tip. The dorsal aspect of the shaft inclines slightly upward; the base is approximately three times the depth of the narrowest middle portion. Ventral spurs on the proximal end are absent, thus contrasting with *Myotis*. The ventral surface is flattened, the lateral margins forming abrupt but shallow runners (Pl. I, e).

Lasionycteris noctivagans.—This bat has the largest baculum of the vespertilionid genera which I have examined. The swollen base tapers gradually to the middle of the cylindrical shaft, thickening imperceptibly toward the distal end which terminates in a slight enlarge-

ment. In one specimen the tip is flattened and truncate at the distal tip, another is rounded. In some specimens the dorsal aspect of the base has a flattened prominence, the bilobed distal extremity protruding beyond the main bulbous portion of the bone. Ventrally, the base is divided into two elongate swellings, their long axis paralleling one another and the shaft. The bone is 3 mm. long (Pl. I, h, i).

Pipistrellus subflavus obscurus.—The baculum is formed in the shape of a Y, the prongs at the proximal position (Pl. I, g). No deflection of these prongs is evident, although a slight concavity along the entire ventral surface may be noted, indicating how closely appressed it lies on the dorsal surface of the urethra. Quite a reverse situation is indicated by Leydig (1857) for *Vespertilio* (*Pipistrellus*) *pipistrellus*. He stated that the bone has two prongs at the distal extremity and two closely appressed swellings at the proximal end. Mathews (*op. cit.*), who figured the baculum in the same species, indicated the structure as flattened in section, largest at its middle part and forked at its distal end, the two prongs lying one on each side of the dorsal surface of the urethra. Thus a marked difference has been recorded for the same species by these authors, and an even greater disparity in form from that of the New World *P. subflavus*.

Pipistrellus hesperus.—This species is considerably smaller than *subflavus*, indeed it is the smallest of North American bats. The baculum, however, greatly exceeds in size and form that of *subflavus*. The long broad shaft, slightly convex above and concave below, terminates distally in a rather abrupt high knob (Pl. I, f). The proximal end is broad, from its median section a rough and constricted portion extends backward. The attached end is similar in appearance to the basal portion of the baculum of many mustelids. The bone has a length of from 2.5 to 3 mm., being four times the length and correspondingly more massive than *P. subflavus*. The disparity in appearance of the two species is very marked. No other such marked interspecific variation has been noted in the several genera studied.

Eptesicus fuscus.—The baculum is an extremely small, distinctly arrow-shaped bone. The distal and proximal points are usually sharp and well marked (Pl. I, m). The dorsum is slightly convex, the venter concave. The length is .8 mm. Gilbert (*op. cit.*) has illustrated the baculum of *Vespertilio murinus* as a pointed spicule, the proximal fifth of which is forked. Chaine (*op. cit.*) figures the baculum of *Eptesicus serotinus* as a slender curved stylet 6–7 mm. in length, without semblance of a fork.

Lasiurus b. borealis.—The baculum appears somewhat like a slipper (Pl. I, n). The high base is directed forward, appearing in dorsal aspect as a rounded spur directed over the shaft. The dorsal sides of the base are concave, joining with the shaft to form broad flanges. Ventrally these flanges form the lateral borders of a deep concavity. The distal tip has a slight rise and is somewhat thickened and broader than the central shaft.

Lasiurus cinereus.—The relatively short baculum is rather stout, the rounded shaft extending into a swollen cylindrical distal portion (Pl. I, o). This terminates in an elevated point, the tip of which is slightly higher than the base. The latter is truncate at its proximal margin. Ventrally the bone is prominently convex except for the proximal fifth, which is slightly concave.

Nycticeius humeralis.—This small bat has a disproportionately large baculum. The bone is distinctive, differing markedly from those of other genera. The structure is blade-like, the distal portion being deep, with convex walls which terminate in an ascending point (Pl. I, p). The thickened proximal portion has a base which forms a prominent angle inclined toward the ventral aspect. On one specimen, a small spur arises from the upper margin of the base and is directed proximally.

Corynorhinus macrotis.—The baculum is arrow-shaped, with rounded borders (Pl. I, j, k). The dorsum is convex, the basal portion rising prominently to its rounded crest. Basally, the median portion of the bone is slightly indented. The ventral surface is concave. The structure resembles a miniature saddle. The baculum of *Corynorhinus* is distinctive from that of the Old World *Plecotus*, which Mathews (*op. cit.*) describes as cylindrical for most of its length, becoming flattened at its proximal end, and produced into two prongs pointing towards the base of the penis.

Dasypterus floridanus.—The slender shaft is constant in width from its inception to the distal end (Pl. I, 1). The tip is not broadened into a knob as one finds in *Myotis*. Proximally the shaft arises abruptly to form a broad rounded base. A slight keel is present on the dorsal aspect. The bone is convex above and deeply concave below. The bone, *in situ*, surmounts the dorsum of the glans penis, the shaft arising at an abrupt angle.

DISCUSSION

The bacula of vespertilionids are useful in defining relationships when considered with skull and skeletal characters. Miller (1907) has considered the classification of the families and genera of bats, based primarily on skeletal and dental characters. He did not remark upon, nor use, the os penis as a structure in classification. The close relationship existing between the genus *Myotis* and *Pizonyx* (Miller and Allen, 1928) is well indicated in the relative similarity of the os penis. Contrariwise, the very great dissimilarity between *Pipistrellus hesperus* and *P. subflavus* is apparent, and suggests generic, or at least subgeneric differences.

Generic differences are marked in most instances, i.e., *Myotis, Lasionycteris, Corynorhinus, Lasiurus*, and *Eptesicus*. The close affinity of *Lasiurus borealis* and *Dasypterus* is indicated in the penis bone.

Further study is needed to determine the usefulness of this structure in chiropteran systematics. The observations recorded above suggest its value in defining specific and generic relationships. In time, and with sufficient material, one may utilize the os penis in classification, combining it with other trenchant characters for taxonomic study.

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Cornell University, Ithaca, New York. Received February 24, 1948.

AGE DETERMINATION, BY USE OF THE BACULUM, IN THE RIVER OTTER, *LUTRA C. CANADENSIS* SCHREBER

BY CHARLES E. FRILEY, JR.

The following study is designed simply to summarize data from an analysis of eighty-three bacula of the river otter (*Lutra c. canadensis*) from the collection of the Division of Mammals, Museum of Zoology, University of Michigan. The report in itself may be an aid to the aging of individuals where the more usual indicators of age are lacking and, in combination with similar studies of other forms, may be of taxonomic value. To my knowledge there has been no other attempt to analyze such a large group of otter bacula, and from this standpoint alone, a report of the findings seems desirable.

Materials.—All specimens are from otter collected in the Upper Peninsula and the northern part of the Lower Peninsula of Michigan. About ninety per cent of the material was secured from the Michigan Department of Conservation—carcasses turned in to it by fur-trappers during the regular trapping seasons of 1940, 1941, and 1943. The remainder was collected prior to these years, primarily in the spring. Unfortunately, forty-nine of the eighty-three bacula have no data, except time of capture, regarding the animals from which they were secured. The data available on the other thirty-four are very rough and practically useless. With the knowledge that all the specimens were collected at the same time of the year, early spring, it appeared that certain age groups could be differentiated on the basis of shape, length, weight, and perhaps volume, when considered together. Such is the plan of approach in this study.

Acknowledgment.—I wish to thank Dr. William H. Burt, Curator of Mammals, for permitting me to work up the material, and Dr. Emmet T. Hooper, Associate Curator, and Dr. Burt, for helpful suggestions during the course of the study.

Definition of terms.—For the purpose of orientation, it will be well to define certain terms. The bone, as stated by Chaine (1925) and others, is divided into three parts; the head, the body, and the tail. The terms "head" and "tail" are somewhat misleading in their connotation in that they describe the two ends of the baculum only as parts of the isolated bone and are not related to the head

and tail of the penis as the terms might imply. The "head" of the baculum is that end nearest, and attached to, the body of the animal—the proximal end of the bone located at the *base* of the penis. The "tail" of the baculum is that end farthest from the body of the animal—the distal end of the bone, located near the extremity of the penis. The "body" is located between the head and the tail. The head of the otter baculum is quite distinct in adults, less so in immature animals. The tail, however, is not distinct and no fine line of demarcation between the body and tail could be found. Roughly, the division point may be considered as the smallest circumference on the distal half of the baculum.

The urethral groove is on the ventral side of the baculum and extends from near the extreme distal end proximad for about one-fifth of the total length of the

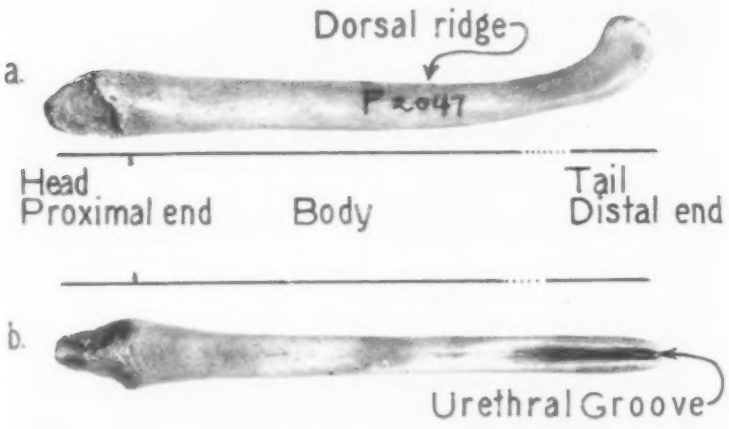

PLATE I

Typical adult otter baculum in (a) lateral view and (b) ventral view

bone. When seen from the distal end, the urethral groove has the appearance of a V of variable width and depth. The dorsal ridge is a more or less sharp crest formed at the junction of the lateral faces on the dorsal side of the body and tail. Plate I shows an average adult baculum in lateral and ventral views with the various parts discussed thus far labeled.

Four age groups have been set up and will be referred to throughout the paper; older adults, younger adults, immatures, and very young. These groups are differentiated on the basis of an index secured by taking the sum of the products of length by weight and length by volume. The indices used to delimit the four groups are: above 845, older adults; 845–650, younger adults; 649–225, immatures; below 225, very young. In addition, all adult bones possess the char-

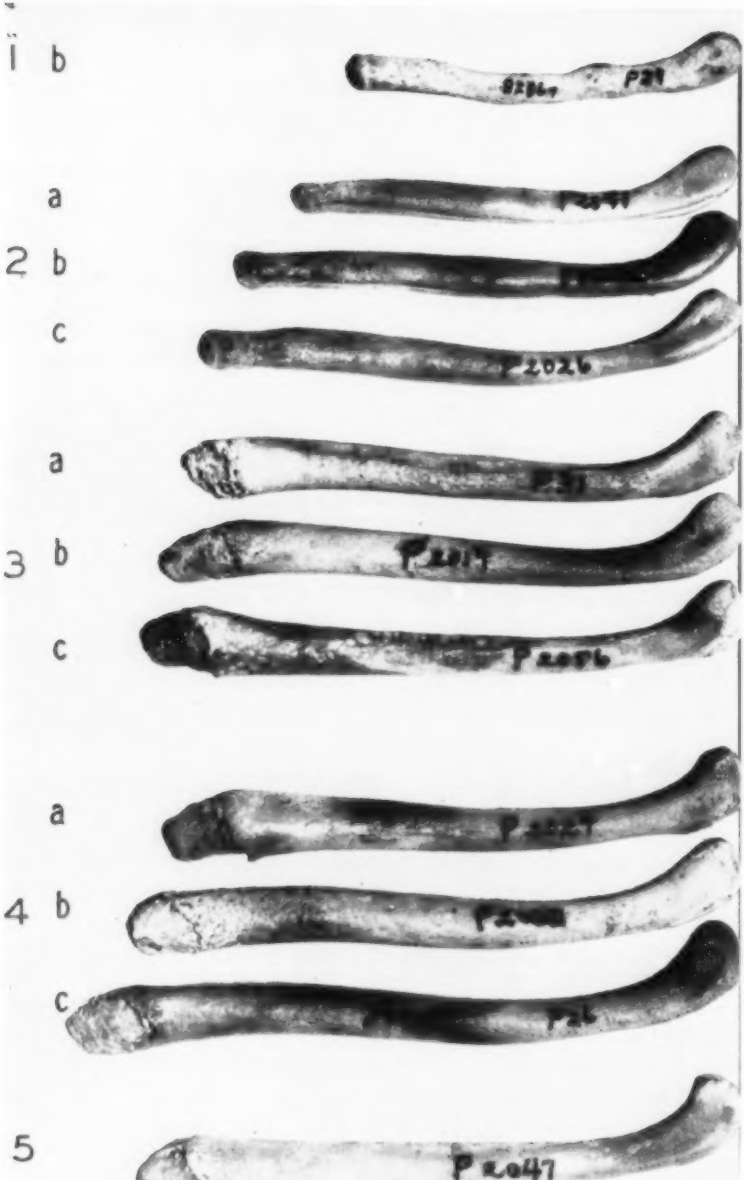

PLATE II

Representative otter bacula from the four age groups and the average adult baculum. (1, very young; 2, immature; 3, younger adult; 4, older adult; 5, average all adults. a, b, and c are the small, average, and large bacula, respectively, of each group.) Natural size

acteristic adult conformation; a flaring of the proximal portion of the body, and a rough, tapering head.

Morphology of the adult baculum.—The river otter baculum may be described as having the shape of a thin S. Eight of the fifty-five adult bacula examined varied from the standard established to delimit the thin S shape. If, as the baculum rests on its ventral side, the maximum distance from the plane, upon which it rests, to the bone, between points of contact, is no greater than 0.1 inch, it is designated as a thin S. Four of these did exceed 0.1 inch and were designated as having an S shape. The other four were without curvature along the proximal half of the ventral side and were designated as having a J shape. Using the straight line made by the central part of the body of the baculum as a line of reference, the head curves slightly ventrad in all but the J shaped bacula and the tail curves sharply dorsad through an angle of from 20 to 30 degrees.

The surface of the head is always rough and sharply distinct from the body. In cross-section it is roughly triangular with the apex ventrad. The base of the triangular cross-section is generally flat, but may have its central portion pushed sharply toward, or bulged slightly away from, the apex. The head accounts for about one-eighth of the total length of the bone.

The body is smooth on its surface, triangular in cross-section, but with the apex on the dorsal side. The change in apex location occurs at the proximal end of the body, distal to the head. The circumference of the body, from its proximal end, decreases rapidly for the first quarter of its length toward the tail, then more slowly to its least circumference at its junction (?) with the tail. Occasional irregularities in body form will be discussed later.

The tail surface is smooth except for slight roughness at the ventral points of the V of the urethral groove. The width of the bone increases as the urethral groove enlarges and deepens distally. The sides of the groove join near the distal end of the bone and the tail continues, without cleft, around to the dorsal side of the bone. The urethral groove varies in length from 18 to 24 mm., except one bone in which the groove is 27 mm. in length and occupies about 22.5 per cent of the total length.

Morphology of the immature baculum.—The baculum of the immature animal differs in shape from that of the adult primarily in that the long, tapering head and the flare of the body near the junction of the head and body are absent. The circumference of the body decreases slightly from its proximal end. A dorsal ridge is evident over most of its length, but disappears as it approaches the proximal end of the body, thus giving the dorsal side a flattened appearance in that region. The short head has about the same circumference as the body and accounts for about one-sixteenth of the total length of the bone. The tail is like that of the adult except that it is slightly smaller. The urethral groove is well formed and occupies about 25 per cent of the total length of the bone. Of the twenty-eight immature and very young bacula examined, three are J-shaped, the remainder have the thin S shape.

Measurements and comparison of age groups.—Measurements upon which groupings of bacula were based are length, weight, and volume. Length was

determined by measuring the greatest straight line distance, to the nearest tenth of a millimeter, between the tips of the head and tail, using a vernier caliper. Weights to the nearest twentieth of a gram were secured with a beam balance. Volume was determined by water displacement to the nearest tenth of a cubic centimeter in a graduated cylinder. The latter is probably the least accurate of the three measurements, because the bore of the cylinders had to be large

TABLE 1.—*Baculum measurements and indices delimiting age groups in the otter*

	OLDER ADULTS	YOUNGER ADULTS	IMMATURES	VERY YOUNG
Number	42	13	25	3
Length (mm.)	Over 93.5*	93.50–87.0	86.90–68.00†	Below 68.0
Weight (gm.)	Over 5.65	5.65– 4.80	4.75– 1.95†	Below 1.95
Volume (cc.)	Over 3.35	3.35– 3.00	2.90– 1.50	Below 1.50
Length × Weight	Over 522	522–400	399–132 (†)	Below 132
Length × Volume	Over 315	315–250	249–100 (†)	Below 100
Length × Weight + Length × Volume	Over 845	845–650	649–225 (†)	Below 225

* Nine exceptions varying in length down to 87.9 mm. Weight and volume of these specimens placed them in the older adult group.

† One exception. This baculum was 3 mm. longer and 0.5 gram heavier than the upper limit of the group. The extreme length and weight caused its three indices to fall within the younger adult limits. It must, however, be considered an immature, since the shape of the proximal end is not yet that of an adult.

TABLE 2.—*Average measurements of bacula with standard deviations and extremes*

	ALL ADULTS	OLDER ADULTS	YOUNGER ADULTS	IMMATURES
Number	55	42	13	25
Ave. length (mm.)	94.92	96.14	90.98	79.77
Standard deviation	±4.46	±4.31	±1.97	±4.98
Extremes	106.4–87.7	106.4–87.9	94.1–87.7	90.0–68.5
Ave. weight (grams)	6.24	6.53	5.31	2.96
Standard deviation	±.80	±.66	±.37	±.82
Extremes	8.65–4.85	8.65–5.60	5.90–4.85	5.25–1.95
Ave. volume (cc.)	3.82	4.03	3.17	1.98
Standard deviation	±.52	±.41	±.13	±.38
Extremes	4.9–2.9	4.9–3.4	3.3–2.9	2.9–1 5

enough to accomodate the curved tail, but is believed to be sufficiently accurate for analysis.

In a study of this nature the manner of preparation of the material will affect the measurements obtained, particularly of weight and volume. If some bacula in a series are prepared by boiling, to help remove the tissues, and others by dermestids or by chemical means, the data will be subject to rather large errors. All specimens used in this study were cleaned by dermestid beetles.

The limits of measurements and indices established to delimit the four age

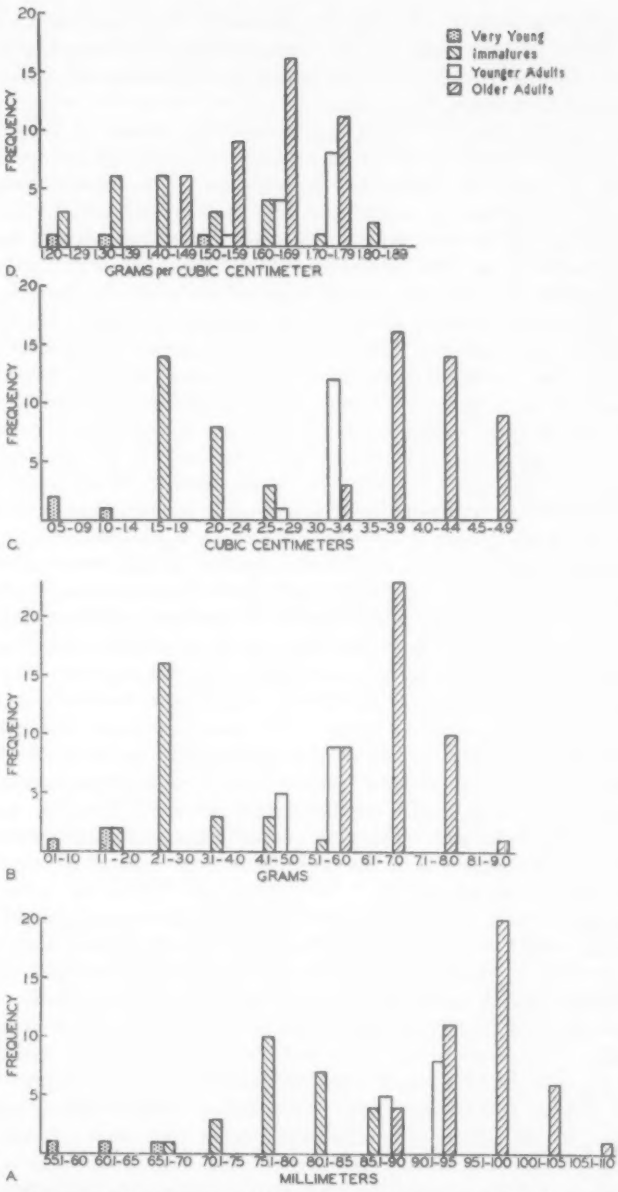

FIG. 1.—Frequency of occurrence of eighty-three otter bacula by length, weight, volume, and density classes.

groups appear in Table 1. A single measurement of one older adult and four younger adults, except as noted in the footnote of the table, was slightly outside the limits of the group to which each was assigned. The other two measurements were well within the group limitations.

Average measurements of each group, except very young, are given in Table 2. The average density of the fifty-five adult bacula is 1.64 grams/cc., while that of the 25 immature bacula is 1.48 grams/cc. The density range of the adults is 1.79–1.42 grams/cc., while that of the immatures is 1.83–1.22 grams/cc. Because the overlap between groups is so great, density appears to have little or no significance in the determination of age in otter.

The frequency of occurrence of the eighty-three bacula by length, weight, volume, and density classes is shown in the histograms of Figure 1.

Development of the baculum.—The examination of the eighty-three bacula used in this study has permitted some limited conclusions to be drawn concerning development of the bone from the very young to the older adult stage.

In very young bones, fusion of the distal edges of the urethral groove is incomplete. The groove itself is quite well formed, and the dorso-ventral height in this region is much greater than it is in the remainder of the bone. The bone is short and spindly and the head is quite porous, even on the surface. The greater portion of the proximal half of the bone is of a cancellous nature with only a very thin, calcified outer layer. Circumferential growth progresses during the latter part of this stage, and length is added primarily at the proximal end of the bone.

In the immature stage, the distal edges of the urethral groove are fused along a rather smooth line. The entire bone increases in circumference, although at an apparently greater rate in the proximal than in the distal portion of the body. The head is still rather porous, and the tail, including the urethral groove, has virtually assumed its definitive shape. The medullary space in the proximal portion of the bone is relatively large; it is much smaller in the distal end. The single medullary canal of the head and body branches near the proximal end of the urethral groove; one branch continues into each side of the bone and flanks the groove to the distal end. The center of mass of the immature baculum falls within the region between 50.25 per cent and 52.5 per cent of the total length, measured from the proximal end.

The change to the young adult stage consists chiefly of a great increase in circumferential growth of the proximal end of the body and the formation of the adult type head. Length increases by addition at the proximal end. Little circumferential growth takes place in the distal portion of the bone. Weight and volume increase rapidly during the change from the immature to the young adult stage. The center of mass has shifted to, and remains in, the region between 43 per cent and 47 per cent of the length, measured from the proximal end.

Length, weight, and volume of the bone, and the shape of the proximal end, are all used in distinguishing immature and adult specimens. Wright (1947) found that juvenile and adult type bacula of the long-tailed weasel (*Mustela frenata*) can be distinguished on the basis of weight alone, and appearance alone. Two otter bacula with adult type heads were placed in the immature group on the basis of the group limits as shown in Table 1. Deanesly (1935) stated, with

regard to the baculum of the stoat (*Mustela erminea*), that the change from the immature to the adult type takes place within a period of one month. If this holds true for the otter, it appears that these two bacula developed the adult type head before having an opportunity to take on the adult length, weight, and volume. Such may be the general course of development from the immature to the adult stage; if true, these two bacula must have been in the process of this rapid transformation at the time they were collected.

The development from younger adult to older adult is one of overall growth; increase in length, weight, and volume. The generally greater massiveness of the older adult baculum is apparent in a series of adult specimens. The medullary space is relatively less in the older adults than in the younger adults and maintains the bifurcation in the region of the urethral groove. Distal to the point of bifurcation, the medullary spaces are elongated dorso-ventrally and extend nearly the entire height of each side of the groove. They remain separated in the tail of the bone.

A selected, representative series of bacula is shown in Plate II to give an idea of development through the four age groups as well as to show some variations within the three older groups. Each of the three central groups, of three bones each, shows a small, an average, and a large baculum of the immature, younger adult, and older adult, respectively. Prediction-line formulae were used to determine what the length, weight, and volume of the small and large specimens in each group should be, and a baculum most nearly fitting these conditions was chosen. The central baculum of each group was selected on the basis of the average figures in Table 2. The small baculum at the top is the mean of the three very young bacula. The baculum at the bottom has been designated as the typical adult baculum; it most nearly approaches the average measurements for "all adults" in Table 2.

Pecularities of form.—Of passing interest may be some pecularities of form found in the otter bacula of the Michigan collection. Two adult bones, not included in the eighty-three measured, appear to have been fractured and subsequently healed. The larger of the two was fractured on the proximal side of its center. Upon healing, the distal half had dropped ventrally without lateral displacement and had twisted to the left (viewed from the dorsal side). The smaller bone was fractured at a point about one-third of its length from the distal end and was displaced to the left. A slight twisting of the distal portion to the right is evident. Both bones appear to have been perfectly sound at the time the animals were captured. An immature baculum, fractured at a point about one-third of its length from the distal end, had healed without vertical displacement and with only slight left lateral displacement. The point of fracture in all cases is perceptibly swollen. The very young baculum in Plate II appears to have had a fracture in all respects like that of the immature bone described above. Development on both sides of the point of fracture seems to have been unimpaired in all the bones. A third adult baculum of extreme length and weight, not included in the measured series, had a rather large, abnormal tuberosity on the proximal end.

Not uncommon in the series is the presence of small nodes on the dorsal ridge.

These nodes occur in the immature and in both the adult groups slightly distal to, or at, the center of the bone, either singly or in pairs. Of the fifty-five adult bacula, five possess paired and five have single nodes. Of the twenty-five immatures, five have single nodes, none have pairs. Thus, roughly 20 per cent possess these nodes on the dorsal ridge.

Summary.—Without the usual supporting data, male river otter of a series may be placed into one of four age-groups—very young, immature, younger adult, or adult—on the basis of length, weight, volume, and general conformation of the baculum. With minor exceptions, an adult may be distinguished from an immature on the basis of the conformation alone. During development of the baculum, the distal portion reaches final shape in the immature phase, the proximal end in the early younger adult phase. Overall growth continues slowly during the late younger adult phase and the older adult phase. Transformation from the immature to the adult type baculum is rapid; it consists of enlargement of the head and the proximal end of the body, followed by increased weight and volume. Linear growth is most rapid within the immature group.

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THE HEART AND ATTACHED VESSELS OF THE OPOSSUM, A MARSUPIAL

By Otis Wade and Patricia Neely

A preliminary study of the blood vascular system of the opossum, part of a project on the anatomy of our native species, *Didelphis virginiana*, now underway here, indicated that the heart and its great vessels had special interest. Some of the findings of a detailed study show unusual structural variations and are made the substance of this advanced report. This project was supported by a Grant in Aid from the Graduate Council of the Graduate College, University of Nebraska.

The material used in this study consisted of twelve specimens, eight females and four males. They included adults, fully mature, and young individuals, the latter being at least a year old. Preservation was with embalming fluid made up of formaldehyde, phenol, and glycerin in the usual way.

Two of the largest hearts, formalin hardened, one from a female and one from a male, were selected for measurements recorded herein with the thought that these would be more meaningful than would measurements of the whole series, which included several subadults. The two measurements taken were length from base to apex and width at the greatest point. The length of the male heart was 44 mm.; the width, 33 mm. The same measurements of the female heart were 44 mm. and 27 mm., respectively.

So far as could be learned from published statements, the opossum heart was not known to have any noteworthy variation from other mammalian hearts, in general, except that Parker and Haswell stated (p. 558); "In the Marsupials the fossa ovalis and annulus ovalis are absent; in the uterine foetus of the Kangaroo the auricles communicate by a fissure, but all trace of this becomes lost before the adult stage is reached."

Since the Monotremata are the only mammals commonly known to show striking variations from the other mammals, and in some respects to resemble the birds (Beddard, p. 66; Kingsley, p. 324; Parker & Haswell, p. 558; Wiedersheim, p. 317), the noteworthy structural variations we found in the opossum heart will be discussed in the light of what is known of the monotremes.

THE MONOTREME HEART

Two structural features in the monotreme heart seen to stand out as the principal things most unlike the "typical" mammal heart and most like the bird. One is the crescentic shape of the right ventricle, seen in cross-section, due to the way the right ventricle is "wrapped around" the left ventricle and the consequent bulging of the left ventricle (septal wall) into the cavity of the right. The other, which is most distinctive of the two, concerns the right atrioventricular valve which is not tricuspid but has a single flap or cusp, opposite the septal wall, and is fleshy due to the absence of chordae tendineae and the direct attachment of the papillary muscles to, and the invasion of their fibers into, the valve. The only statement at variance with this description was noted in Kingsley (p. 324);

"In the monotreme both atrioventricular valves consist of three cusps, but elsewhere the right is tricuspid, the left bicuspid."

THE OPOSSUM HEART

The right ventricle.—The right ventricle of the opossum shows the crescent shape (Fig. 1*a*) to so marked a degree that it approaches closely that of the bird and what is evidently also the case in the monotreme. This does not imply that the crescent or semilunar shape of the right ventricle is something distinctive of birds and not of mammals. Evidently this condition obtains in mammals generally, but the difference is one of degree—the extent to which the right ventricle surrounds the left. It is great in the bird, the monotreme, and the opossum, while, apparently, it is less marked in other mammals. Although Beddard states (p. 66), in commenting on the similarity of the bird and monotreme heart

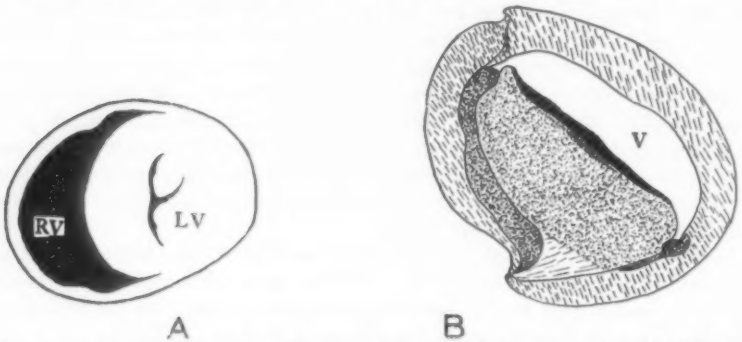

FIG. 1.—A. Transverse section of opossum heart showing crescent shape of right ventricle. RV, right ventricle in diastole; LV, left ventricle in systole. × 1½. B. Right atrium of opossum heart opened. V, single cusp of atrioventricular valve occluding orifice. × 2½.

on this point, ". . . on the other hand in the higher mammal the two cavities lie side by side." Such standard texts on human anatomy as Gray (p. 529), Morris (p. 588), and Cunningham (p. 1145) all indicate that the semilunar shape of the right ventricle is due to the bulging of the left ventricle into it. We have verified this in several human hearts, but have found this condition much less noticeable.

The atrioventricular valves.—The principal difference in the opossum heart, as in the monotreme, is found in the right atrioventricular valve where there is one instead of the usual three flaps or cusps (Pl. I). This does not encircle the atrioventricular orifice at its attachment, but extends only along the sternocostal border and thus the flap is opposite the ventricular septum and on the sternocostal side. In closing the orifice this cusp must push against the septal wall and the septal rim of the orifice. This was demonstrated quite effectively in one large, well-developed specimen by forcing the flap into the orifice to effect a closure (Fig. 1*b*).

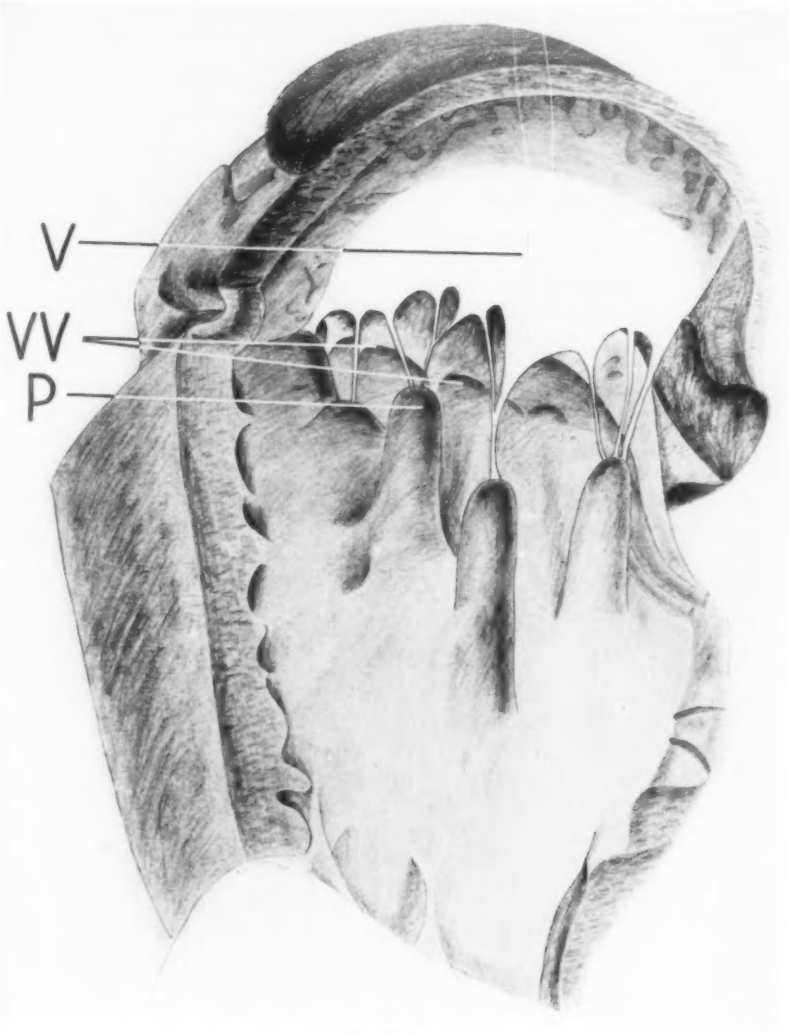

PLATE I

Right ventricle of opossum heart with sternocostal wall incised and reflected. V, valve flap; VV, vestigial valve tissue on septal side (label lines point to edge of this fold and a shallow pocket back of it)

Traces of a narrow strip or fold of tissue, largely membranous, on the medial (septal) side with the free edge closely attached to the wall by fibers or tendinous cords represent an imperfect or vestigial medial cusp (Pl. I). This tissue is

always more strongly developed in the region where, in the tricuspid condition, the posterior cusp is located. Among the specimens examined there is considerable variation in the amount of this tissue and in the extent of development. In no case have we seen a sufficiently developed cusp that likely would be functional. Beddard (p. 66) reports the presence of similar vestiges in the monotreme, but with more variations, as indicated in the following statement: ". . . the septal half (*i.e.* that turned towards the interventricular septum) is either entirely absent or more generally represented by a small bit of membrane; nevertheless I found recently in an *Ornithorhynchus* heart a complete septal half to the right auriculo-ventricluar valve."

It will be noted then that the right atrioventricular valve in the opossum bears strong resemblances to the monotreme, but it differs in always being membranous throughout, not fleshy, and in having tendinous cords connecting it with papillary muscles. In only two cases was there direct attachment of a muscle to the flap, but in neither did muscle tissue extend into the valve.

The atrioventricular valve on the left side is the same as in other mammals, i.e. the valve guarding the left atrioventricular opening is a mitral, made up of two cusps. We know of no exception to this.

The papillary muscles.—In the right ventricle these vary between two and four distinctly developed muscles, though they are variable in size. The commoner number is evidently three, based on the specimens examined, but two appear in about one third of the specimens. We noted only one case with four muscles. Occasionally a muscle will show a distinct double condition. At variance with what is true of the human heart, the papillary muscles in the right ventricle invariably all arise from the medial wall, side by side; there is no "anterior" papillary muscle as in the human since none springs from the sternocostal wall. Some tendinous cords attached to the valve flap arise directly from the wall of the septum or from small muscular eminences on it (Pl. I).

In the left ventricle there are regularly two papillary muscles, an anterior and a posterior, and each with tendinous cords passing to both flaps, as is commonly true of other mammals.

The right atrium and its veins.—Three caval veins enter the right atrium; a posterior caval and a right and left anterior caval. The right precaval opens anteriorly into the atrium. The postcaval and the left precaval enter in close proximity—the left slightly posterior and to the left of the postcaval at the posterior limits of the atrium. The precavals are without valves in the entrances, but the postcaval displayed vestigial valves in the entrance in every instance. At least one clearly discernible membranous cusp or strip of tissue was present. A second strip of tissue (not a complete cusp in any we examined) appeared opposite the first in about half the cases. The left precaval, as it crosses the dorsal aspect of the heart, expands appreciably, sometimes equal in size to the postcaval, into a distinct sinus-like (coronary) structure; in the terminus of this is the small opening of the coronary vein. No fossa ovalis is apparent on the atrial septum although in five specimens a roughened area probably marked its site.

The left atrium and its veins.—Into the dorsal wall of the left atrium open the

pulmonary veins. These openings vary in size and number, the common number without doubt being one, which is always large. In two specimens four veins entered separately, and in two others there were two openings, two veins from each lung joining before entering.

The aorta and its proximal branches.—There are two coronary arteries passing to the heart in the usual manner. One specimen had the two arising as one and then dividing almost immediately. The subclavian and carotid arteries follow a definite pattern in branching from the aortic arch. There is an innominate artery from which both carotids and the right subclavian branch, the latter branches off first and then almost at once the innominate terminates by dividing into the two carotid arteries. The left subclavian arises separately a little distance out on the arch. All specimens examined had this plan, but undoubtedly variations would appear in a larger series. The aorta has the customary semilunar valve of three cusps in its entrance.

The pulmonary artery.—This is equipped with a semilunar valve of three cusps and otherwise presents no differences of note.

SUMMARY

1. The right ventricle of the opossum heart has a decidedly crescent shape—as extreme as that of the monotreme.

2. The right atrioventricular valve has but one developed and functional flap. This is opposite the septum, is membranous, without muscle tissue in it, and is attached by chordae tendineae to papillary muscles springing from the septal wall and by tendinous fibers directly to the wall itself. In having but a single cusp it resembles the monotreme condition and is unlike that in other mammals where the situation is known.

3. The left atrioventricular orifice is guarded by a bicuspid valve which is attached by tendinous cords to two papillary muscles in the customary manner.

4. No fossa ovalis is present in the atrial septum. A postcaval and two precaval veins open into the right atrium, the right precaval near its anterior border and the left precaval and postcaval very close together at its posterior border. These three veins are usually of about equal size. Valves or vestiges of them are in the entrance of the postcaval, but the others show no trace of them.

5. The pulmonary veins most often enter the left atrium through one opening, which then is quite large, but there may be two or four openings and these may vary in size.

6. The carotid and subclavian arteries have a definite pattern of origin—the two carotids and the right subclavian spring from an innominate very close together and the left subclavian arises from the aorta a short interval beyond the others.

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THE DALL PORPOISE, *PHOCOENOIDES DALLI*, IN ALASKA

BY VICTOR B. SCHEFFER

In the summer and fall of 1947 and the fall of 1948 the Fish and Wildlife Service research vessel *Black Douglas* cruised in waters from Vancouver Island, British Columbia, to Attu Island, Alaska. Five biologists were aboard at one time or another; Karl W. Kenyon, William H. Sholes, Robert Z. Brown, Rául Vaz-Ferreira, and the writer. In our spare time we harpooned five specimens of the Dall porpoise from the bow of the ship, using a modified Coast Guard .30-caliber line-throwing device. The skulls of the porpoises have been deposited in the U. S. National Museum. The stomach contents are being examined and will be described in a later paper.

Range.—Farthest west: Groups seen on six occasions on July 4 in the Bering Sea 50 to 75 miles NW of the Islands of Four Mountains. Farthest east: A group seen in Queen Charlotte Strait on August 11 and a group seen ten miles off the west shore of Vancouver Island at Latitude 50 on September 7. Farthest from land: A group seen in the Gulf of Alaska 60 miles E Kodiak Island on August 5 and a group seen in the Gulf of Alaska 50 miles S Yakataga Island on September 12. Most abundant (in order of decreasing frequency): Southeast Alaska, including Clarence Strait, Dixon Entrance, and Icy Strait; Shelikof Strait, especially the NE end; and Prince William Sound.

We did not see Dall porpoises in the narrower channels of the Inside Passage. Here, for example in Wrangell Narrows and Graham Reach, we generally saw a few harbor porpoises, *Phocoena vomerina*. The Dall porpoise was most abundant in wide straits and marine crossroads.

Grouping.—In 72 recorded observations we saw a total of about 350 porpoises. There were commonly two to four in a group, with a range of one to about 25. The largest group passed the ship on September 9 in Clarence Strait NW of Ship Island. Earl Bright, veteran fleet engineer of the Fish and Wildlife Service, says that he usually sees porpoises here.

Our observations did not reveal any seasonal variation, either in the range or the grouping of the porpoises, although such variations probably exist.

We noted specifically "one large and one small" Dall porpoise in Icy Strait on September 11. Perhaps the small one was a young of the year. No one knows when or where the Dall porpoise gives birth to its young. At other times,

small porpoises played at the bow of the ship along with the adults that we were attempting to capture. Future collectors should try to take a few of these young.

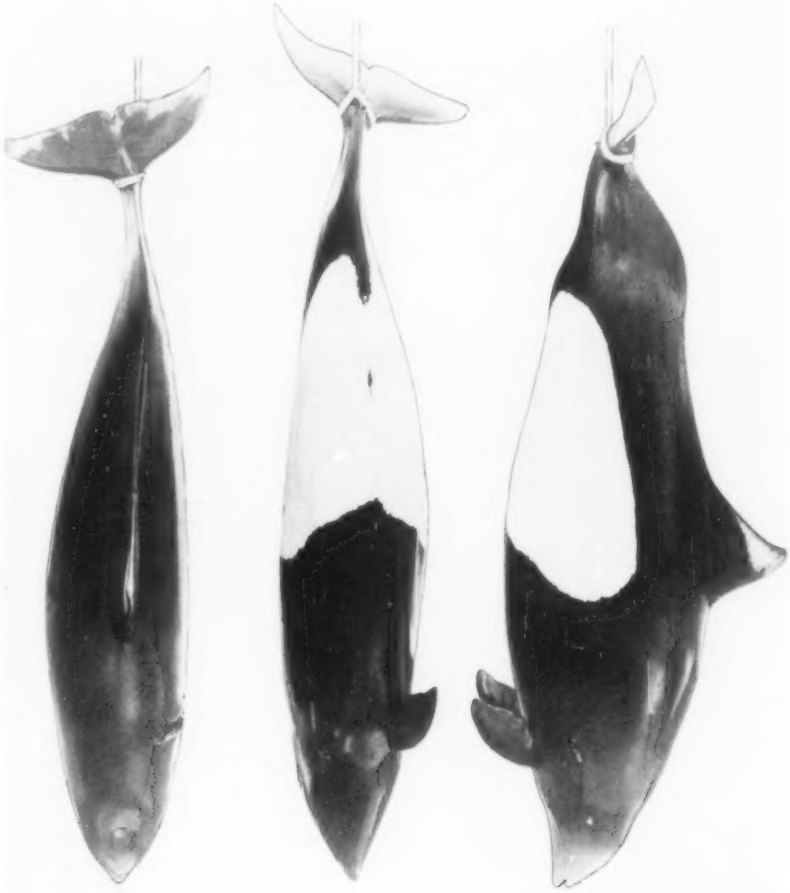

PLATE I

Three views of adult male Dall porpoise No. 126. See Table 1 for measurements (Photos 2131-2133, retouched)

Mr. Sholes saw five killer whales, *Grampus rectipinna*, moving along in a straight line with five or six Dall porpoises playing near them, off Cape Uyak, Alaska Peninsula, August 4. Several times we saw Dall porpoises at night sporting at the bow of the ship, their outlines clearly revealed by luminescence.

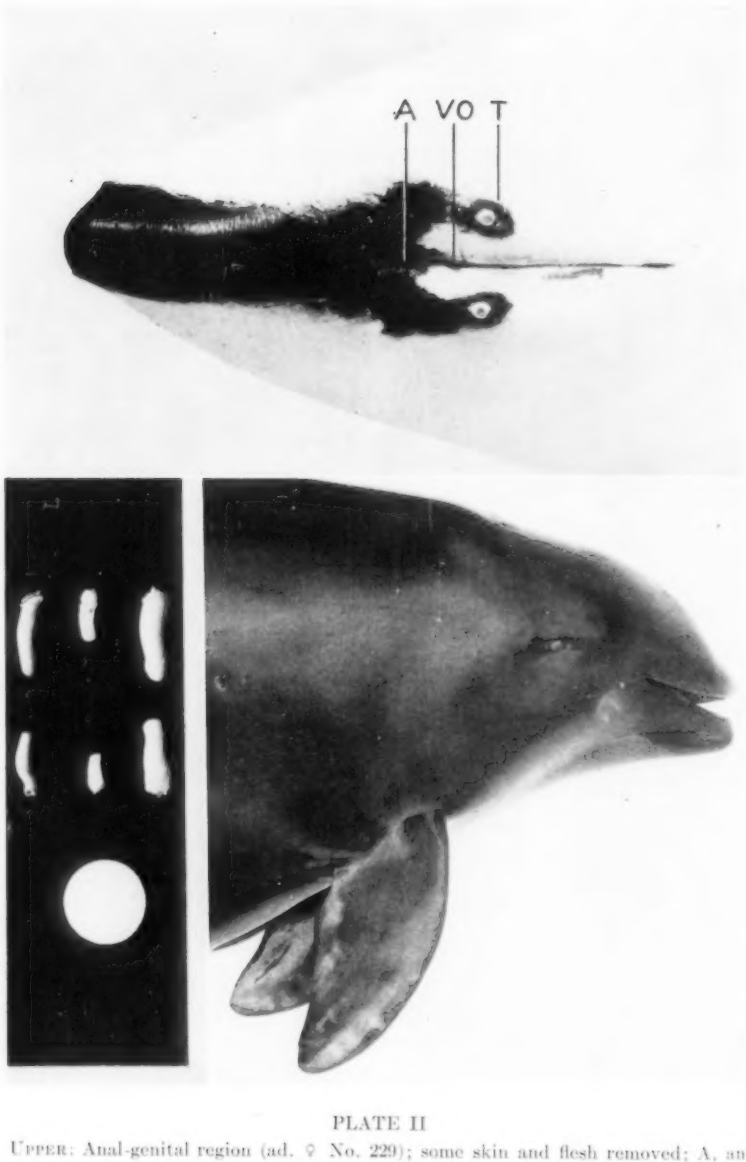

PLATE II

UPPER: Anal-genital region (ad. ♀ No. 229); some skin and flesh removed; A, anus; T, teat; VO, vaginal opening; distance between centers of teats, 40 mm. (Photo 2292).

LOWER RIGHT: Head region of subadult male No. 228 (Photo 2262).

LOWER LEFT: Selected teeth; left, adult male; center, adult female; right, subadult male. Top row from middle of right maxilla; bottom row from middle of right mandible; Nos. 126, 229, 127; white disc, one-fourth inch in diameter (Photo 2352).

Notes on individual specimens (*Table 1.*)—BDM 126 (USBS 33122X), Pl. I; adult male, shot in Meter Bight, Stikine Strait, Alaska, May 17, 1947. Thickness of belly skin, 3.5 mm.; thickness of belly blubber, 18 mm.; length of pelvic rudiments, 56.7 and 58.0 mm.

BDM 127 (USBS 33123X); subadult male, shot 3 miles NW Spasski Island, Icy Strait, Alaska, May 24, 1947. Diameter of ear opening, 0.5 mm.; vibrissae pits, 12 or more on each side of snout; thickness of belly skin, 4.5 mm.; thickness of belly blubber, 19 mm.

BDM 228 (USBS 33124X); subadult male, shot 2 miles NW Storm Island, Queen Charlotte Strait, British Columbia, August 11, 1947. The iris snapped open at death to impart a blue-green luster to the eye; the so-called death shine. Diameter of ear opening, 0.5 mm. At the base of the tail notch the adjacent sides of the flukes overlapped 10 mm. Length of pelvic rudiments 42.5 and 43.5 mm.

BDM 229 (USBS 33125X); adult female, shot in the Gulf of Alaska, 59° 10′ N, 141° 50′ W, on September 12, 1947. Uterus large and flabby; no visible fetus; no milk in mammae; each of the two mammae 7 mm. in diameter and 15 mm. long in protruded position (Pl. II). Length of pelvic rudiments, (R) 34.2 mm. and (L) 32.6 mm.

BDM 291 (USBS 33403X); adult male, shot in Frederick Sound, Alaska, November 8, 1948. Length of stretched penis 167 mm.; length of pelvic rudiments, (R) 54.7 mm. and (L) 56.1 mm.

Sex and age distinctions: *Body form.*—The largest male and the largest female in our collection weighed about the same, 245 and 222 pounds, respectively. The dorsal fins of all specimens were similar in outline. On the underside, posterior to the anus, the males exhibited a pronounced bulge, not apparent in the female. The posterior margin of the tail flukes of the adults was sinuous, while that of the subadults was straighter. The umbilical scar of the adults was difficult to see. On the subadults it appeared as a pigmented depression.

Color.—The adults were black and white; the subadults, very dark gray and very light gray. There were slight differences in the color patterns of the adult males, the adult female, and the two subadult males. In all five specimens there were mottled gray areas on the tip of the dorsal fin and the posterior margin of the tail; also on the flippers, though less pronounced. In the subadults, the head and face and the region between the vent and the tail were paler than the back. Subadult male No. 127 had a faint but sharply delimited patch of gray at the tip of the lower jaw (chin). A narrow black line ran along the belly between the vent and the thorax. This line was absent from the other four specimens.

On subadult No. 127 the eye was circled by a dark ring which, in turn, was circled by an indistinct gray one. The ear was circled by a faint dark ring 9 mm. in diameter.

The white anal patch extended posteriorly one-fourth of the distance from the anus to the base of the tail flukes on the males, one-half of the distance on the female.

Dentition.—The teeth of the Dall porpoise are weak, small, and poorly rooted.

In cleaning the skull, one must carefully preserve the layer of tissue around the teeth, lest they fall out. Judging from the five specimens at hand, the teeth in the adult are smaller than those in the subadult. With increase in age the crown wears off and the root apparently decreases in diameter (Pl. II).

TABLE 1.—*Measurements of 5 Dall porpoises from Alaska and British Columbia, 1947 and 1948 (In millimeters unless otherwise stated)*

	ADULT MALES		ADULT FEMALES	SUBADULT MALES	
Specimen No. (BDM Series)	291	126	229	127	228
Length, snout to base of tail notch	1841	1730	1780	1670	1580
Weight, pounds	245	224	222	168	159
Girth immediately behind flippers	1030	975	955	917	915
Maximum width of tail flukes	457	498	452	421	449
Snout to tip of dorsal fin	918	938	911	816	840
Snout to insertion of flipper	297	300	312	310	285
Axillary length of flipper	146	197	150	173	145
Maximum width of flipper	98	97	96	92	95
Height of dorsal fin	161	166	155	132	152
Tail notch to center of anus	585	536	543	500	504
Corner of mouth to snout	115	118	119	114	109
Snout to center of eye	222	230	214	215	206
Dimensions of eye opening	11 x 20	11 x 20	11 x 19	8 x 17	9 x 18
Snout to slit of blowhole	227	238	215	221	219
Maximum width of blowhole	47	38	42	41	41
Projection of lower jaw beyond snout	8	4	6	5	3
Center of ear to center of eye	65	70	67	70	67
Number of visible teeth, UR	23	21	0	20	18
Number of visible teeth, UL	25	21	0	20	18
Number of visible teeth, LR	26	27	0	24	21
Number of visible teeth, LL	25	27	0	25	23
Maximum condylobasal length of skull	338	337	319	309	319
Maximum (zygomatic) breadth of skull	195	198	189	180	181

TABLE 2.—*Liver analysis, Dall porpoises*

	WEIGHT OF LIVER IN GRAMS	WEIGHT OF LIVER IN POUNDS	PER CENT OIL	VITAMIN A UNITS PER GRAM	VITAMIN A, MILLIONS OF UNITS PER POUND	VITAMIN A, MILLIONS OF UNITS PER LIVER
Adult male No. 126	1660	3.65	3.76	4150	0.071	0.259
Adult female No. 229	2005	4.41	3.35	19500	0.295	1.302
Subadult male No. 228	1070	2.64	4.26	25800	0.499	1.176

In subadult male No. 127, a typical tooth from the middle of the upper row was curved and slightly flattened; dimensions, 1.5 x 2.0 x 7.0 mm. It had a flared crown exposed for 1.5 mm. of its length.

In adult male No. 126, a typical tooth from the middle of the upper row was curved, slender, and round; dimensions, 1.4 x 1.4 x 6.5 mm.; exposed for 2 mm. of its length.

In adult female No. 229, a typical tooth from the middle of the upper row was curved, slender, and round; the crown worn off squarely; dimensions of tooth, 1.2 x 1.2 x 4.0 mm. No part of the tooth was exposed.

As shown in Table 1, the number of teeth visible in the freshly killed specimen varied from 99 in the largest male to none in the adult female. In the adult female, serrations along the gums took the place of exposed teeth. The serrations were about 5 mm. from crest to crest and were 3 mm. deep. We failed to note whether the gum tissue had actually grown over the stumps of the teeth, but it is our recollection that it had. After we had cleaned the skulls we were able to estimate the number of teeth and vacant alveoli in the jaws of adult male No. 126 as 28 in each half of the upper and 34 in each half of the lower. The adult female appeared to have 25 teeth and alveoli in each half of the upper jaw. In the lower jaw the alveoli were shallow and difficult to count.

Liver analysis.—We saved the livers of three Dall porpoises for later study in the Fish and Wildlife Service Laboratory, Seattle. They were kept frozen until May 4, 1948, when they were analyzed for vitamin A potency by Bruce Sanford and Karl W. Kenyon. Generally speaking, the vitamin A potency of liver varies widely with the species and with the individual (Table 2). For this reason, our sample of only three livers is too small to serve as the basis for important conclusions. The sample suggests, though, that the Dall porpoise liver is poor in oil and fairly rich in vitamin A per gram of oil. The vitamin A value per gram of oil seems to lie somewhere between the values for cod and halibut liver oils. In examining porpoise No. 228 at the time of its death we could not locate the gall bladder. Later, in the laboratory, we examined the liver of this animal as well as the livers of No. 126 and No. 229 and could not find the bladder. We are left wondering whether the Dall porpoise lacks a gall bladder or whether it has one which is small and embedded in the liver.

U. S. Fish and Wildlife Service, Seattle, Washington.

MUSKRAT WEIGHTS AND SEX RATIO IN THE RIVERBEND MARSHES OF WAYNE COUNTY, NEW YORK

By William S. Heit

The muskrat marshes of central and western New York State have established themselves as producing the finest muskrat fur in North America. Pelts from these marshes are especially desirable to the fur trade and particularly to the Hudson seal manufacturers because of their dense, long under fur and large size.

My father, Ezra S. Heit, has owned and operated one of these marsh areas since 1916, and the writer has trapped these muskrats (*Ondatra z. zibethica*) since 1925. The collection of data regarding the muskrats of the Riverbend marsh was instituted at the suggestion of Dr. William J. Hamilton, Jr., of Cornell University, who has visited this area and adjoining marshes (Montezuma marshes) numerous times in his study of fur-bearing animals of New York State. During the trapping season of 1938, 1939, and 1940, the weights and sexes of 275 muskrats were recorded in an effort to establish factual basis for the high regard of these muskrats by the fur industry.

Description of the area.—The habitat from which these muskrats were trapped comprises eighty-five acres of typical central New York cattail marsh with open ponds and bordering dense cattail growth. The history of this marsh may be significant since prior to flooding by the New York State Barge Canal the land was known to be extremely fertile and productive to agriculture. Wheat production ran as high as forty bushels to the acre in this fertile river bottom, which has a clay hardpan beneath ten to eighteen inches of topsoil. Such land probably produces a more nutritious growth of cattail and other aquatic vegetation than would poorer soil. This may contribute, through extra food, to the size and texture of the muskrat pelts. The marsh area is flooded each spring by water backing up from the Clyde River and Barge Canal. Flood waters frequently rise to a depth of three feet above normal.

Relatively light trapping operations were carried out during the three seasons that these records were taken. Muskrat population had suffered severely from summer drouths of the past four years (1933–37). The drouth, combined with an extreme low water level in the winter, greatly reduced the muskrat numbers in the area. The population was at a maximum density only in a few deep holes where the water level had been adequate during summer and early fall.

The trapping season begins January 1 in Wayne County and extends through March. When the winter is long and severe, most of the trapping operations are necessarily conducted through the ice in runways, feeding houses, and bank burrows. The marsh usually breaks up between March 15 and April 1, and at that time the largest catch is made.

Weights.—In recent years several authors have added to our knowledge of weights of muskrats. Errington (1939) gave the average weight of thirty-four muskrats, taken in Northwestern Iowa in November and December, as 2.41 pounds, and that of ten summer specimens from the same area as 2.49 pounds. Baumgartner and Bellrose (1943) stated that Illinois adult muskrats averaged 2.7

pounds and that Michigan adults averaged 2.3 pounds. Sub-adults from Illinois averaged 2.1 pounds and from Michigan 1.9 pounds. Schoonmaker (1929) gave the average of eleven New York muskrats as 2.34 pounds; Seamans (1941) found that, at Lake Champlain, Vermont, ninety-four males averaged 2.77 pounds and fifty-six females, 2.46 pounds, or 2.66 pounds for the 150 individuals. Grimm (1941) recorded weights of forty-seven muskrats trapped in Northwestern Pennsylvania during December and January with males averaging 2.47 pounds and females, 2.26 pounds. In 1943, Dozier (1945: 233) recorded a muskrat from the Montezuma National Wildlife Refuge, Seneca Falls, New York, that weighed 5 pounds 4 ounces. He gave the average weight of 2152 males and 1767 females, trapped January 1–March 20, as 3.6 pounds and 3.3 pounds, respectively. He further

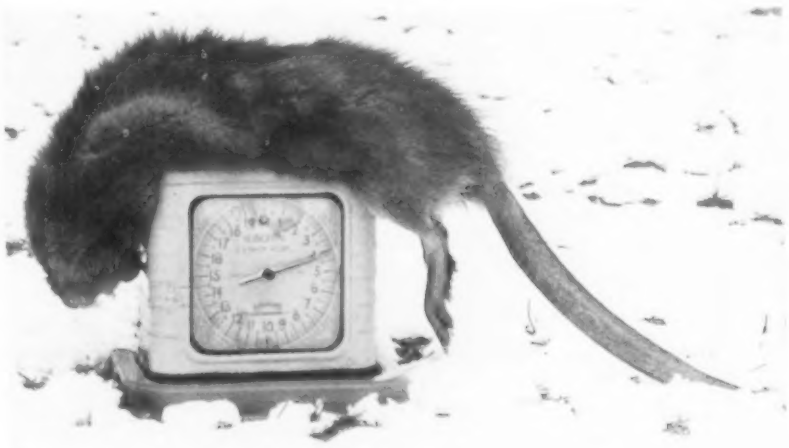

PLATE 1

Four and one-quarter-pound muskrat trapped February 9, 1940, in Riverbend Marsh

pointed out that this was an unusually favorable year with abundant food for the muskrats. A majority of these muskrats were extremely fat, frequently having as much as eight ounces per animal. This is the highest recorded average for muskrats in the United States and indicates a superior type of habitat and food in the area.

The average weight of 275 muskrats trapped in the Riverbend marshes in January, February, and March, in 1938, 1939, and 1940, was 2 pounds 11.4 ounces. The heaviest taken was a male that weighed 4 pounds 8 ounces. This muskrat, which Ezra S. Heit states was one of the largest taken by him in twenty-five years of trapping, was caught in a runway under the ice in the cattail marsh on January 9, 1940. Four other males weighed four pounds or more each (Pl. 1). The smallest male weighed 1 pound 8 ounces. The largest female taken weighed 3 pounds 10 ounces, closely followed by five others that weighed 3

pounds 8 ounces each. The smallest female weighed 1 pound 12 ounces. The average weight of 198 males was 2 pounds 11 ounces and of 77 females, 2 pounds 16 ounces. The muskrats were weighed prior to skinning. These weights were taken throughout the trapping season and were recorded on a reliable scales to the nearest ounce.

Sex ratio.—Dozier and Allen (1942) reported that of the 9304 muskrats (*Ondatra z. macrodon*) sexed on the Blackwater Refuge in Maryland, 5210 (56 per cent) were males and 4094 (44 per cent) were females. Seamans (*ibid.*) reported 65.4 per cent males and 34.6 per cent females in the Lake Champlain area of Vermont. Errington (1939) examined eighty-six new-born young in their nests and found that 58.1 per cent were males.

Several old trappers maintain that they catch more males in the early part of the season and fewer in the spring. Sylvester C. Vanderbilt of Savannah, New York, places his traps in certain types of sets in which greater numbers of males will be taken, particularly in the spring. Ezra S. Heit is firmly convinced that certain types of sets will catch mostly male muskrats.

Both external and internal examination of the 275 muskrats trapped in the Riverbend marshes showed 198 males (72 per cent) and 77 females (28 per cent). Examination of ten litters containing sixty-eight kits, in April and May, 1940, revealed that 54 per cent of the young muskrats were males.

Summary.—Data based on 275 muskrats gave the average weight of 198 males as 43.8 ounces, and 77 females as 42.4 ounces. The average of both males and females is 43.4 ounces. Several large males were recorded, one weighed 4 pounds 8 ounces. The largest female weighed 3 pounds 12 ounces. Information on sex ratio shows a large percentage of the take as males, 72 per cent, indicating that the study of trapping techniques might prove useful to marsh management.

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THE WEIGHT OF WILD BROWN RATS AT SEXUAL MATURITY[1]

By David E. Davis

The size of rats at sexual maturity may differ from place to place depending upon a variety of factors. For studies of population dynamics it is valuable to know at what age rats become mature and are able to reproduce. Physiological characters such as size (weight) may be useful to determine the age of wild rats, but size has only an approximate correlation with chronological age (Davis and Winsor, MS).

To determine the size at sexual maturity, rats were collected in residential areas of Baltimore and also on a farm outside the city. The city rats lived outdoors most of the time and, although some individuals had access to basements, none came from strictly indoors locations. The farm rats lived in unheated barns and sheds. The city rats were brought to the laboratory and autopsied. The farm rats were measured alive on the spot and then released (Davis and Winsor, MS). For the city rats, the following pertinent data were obtained: weight, vagina perforate or imperforate, visibly pregnant or not (Emlen and Davis, 1948), testes scrotal or abdominal. For the farm rats, the following data were obtained: weight, vagina perforate or imperforate, testes scrotal or abdominal.

Sexual maturity of the male.—For the farm males, it was possible to determine the weight at which the testes descend into the scrotum (Table 1). From these data it was calculated (by the method of Leslie, *et al.*, 1946) that the weight at which 50 per cent of the rats on the farm had scrotal testes was 136 grams (Fig. 1). The age of farm rats weighing 136 grams has been found (Davis and Winsor, MS) to be about 18 weeks.

Table 1 shows the occurrence of several individuals of large size, but with abdominal testes. Most of these were sick rats; others apparently may retract the testes when frightened. Since the few large rats with abdominal testes occurred in all months of the year, it is concluded that there is no seasonal regression of the testes, as occurs in many wild rodents.

The weight at which the testes of city rats descend into the scrotum is also shown in Table 1. The weight at which 50 per cent of the rats have scrotal testes is 119 grams (Fig. 1). The difference between the 50 per cent points of farm and city rats is statistically significant at the .01 level. The difference is even more striking when the ratios of the 50 per cent points to the mean weights are considered. The ratio for farm rats (136/201 = .68) is significantly different from the ratio for city rats (119/264 = .45) at the .001 level. It is thus noteworthy that the city rats matured (testes descend) at a smaller size than did the farm rats, and yet the city rats grew to a much larger size (Table 1). It seems

[1] Contribution from the Rodent Ecology Project of the Department of Parasitology, School of Hygiene and Public Health, The Johns Hopkins University. The work reported in this paper was conducted under a grant from the International Health Division of the Rockefeller Foundation.

likely that the factors which favor greater growth also favor early reproductive maturity. In another investigation (Davis and Hall, MS), the maturity of rats collected in poultry warehouses was studied. These rats lived almost exclusively indoors and the buildings were partially heated. There was an ample supply of chicken mash and frequently dead poultry available. The weight at which 50

TABLE 1.—*Relation between body weight and position of testes or perforation of vagina*

WEIGHT, GRAMS	POSITION OF TESTES				PERFORATION OF VAGINA			
	City Rats Examined	Per cent Scrotal	Farm Rats Examined	Per cent Scrotal	City Rats Examined	Per cent Perforate	Farm Rats Examined	Per cent Perforate
0– 24	8	0	11	0	9	0	4	0
25– 49	76	12	97	1	65	2	91	1
50– 74	131	15	86	0	128	20	108	13
75– 99	120	33	53	11	116	27	104	45
100–124	81	40	80	30	88	62	79	77
125–149	58	74	45	51	85	79	76	96
150–174	66	88	63	67	78	95	97	99
175–199	45	76	45	80	70	100	83	100
200–224	59	93	52	89	86	100	109	100
225–249	61	88	52	94	70	100	69	100
250–274	50	96	58	97	85	100	87	100
275–299	59	97	79	94	85	100	92	100
300–324	53	93	85	98	74	100	72	100
325–349	76	97	62	98	87	100	41	100
350–374	66	94	58	97	94	100	16	100
375–399	67	99	37	92	83	100	19	100
400–424	65	95	28	100	96	100	2	100
425–449	65	92	10	100	86	100	2	100
450–474	70	98	1	100	59	100		
475–499	48	100			58	100		
500–524	43	93			38	100		
525–549	25	96			14	100		
550–574	22	100			10	100		
575–599	13	100			8	100		
600–624	3	100			3	100		
625–649	2	100			2	100		
Totals.....	1432		1002		1677		1151	
Mean Wt.....	264		201		261		179	
Stan. Dev.....	162		104		146		89	

per cent of these rats had scrotal testes was 105 grams. The difference between poultry warehouse rats and farm rats is significant, but the difference between poultry warehouse rats and city rats is not significant. (The probability is .07 of getting such a difference by chance.)

Sexual maturity of the female rats.—The data for the farm rats provide information concerning the body weight at the time of perforation of the vagina (Table 1). The weight at which 50 per cent of the farm rats have perforate vaginae is 88 grams (Fig. 1). The age when the animals attain this weight is about eight weeks (Davis and Winsor, MS).

The perforation of the vagina in relation to weight is shown in Table 1 for city rats. The weight at which 50 per cent of the city females have perforate vaginae

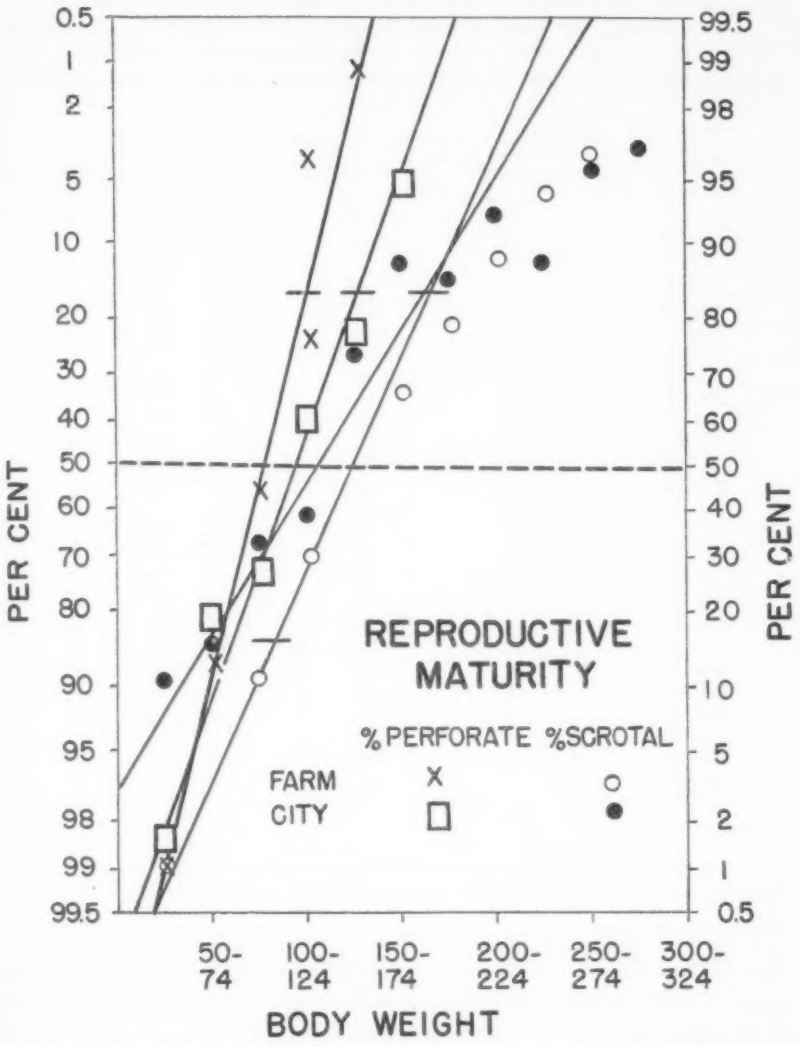

FIG. 1.—Body weight in relation to per cent scrotal and per cent perforate for city and farm rats.

is 105 grams (Fig. 1). The difference between the 50 per cent points for the city and farm females is statistically significant at the .01 level. The females from

the city are larger than the females from the farm and reach the stage of perforation of the vagina at a somewhat larger size. But, when the ratios of 50 per cent points to mean weights of the rats are considered, it is found that the farm rats reach vaginal perforation at a relatively larger size (88/179 = .50) than do the city rats (105/261 = .40). When the significance of these ratios was calculated the difference was found to be significant at the .01 level. Thus, it is seen

TABLE 2.—*Relation between weight and pregnancy and lactation of city rats*

WEIGHT, GRAMS	TOTAL RATS	PER CENT PREGNANT	TOTAL RATS	PER CENT LACTATING
0– 24	9	0	9	0
25– 49	64	0	65	0
50– 74	122	0	117	0
75– 99	105	0	107	0
100–124	80	1	79	0
125–149	78	0	78	0
150–174	77	3	75	1
175–199	67	0	67	0
200–224	86	12	83	3
225–249	69	13	67	5
250–274	84	16	81	5
275–299	83	33	84	7
300–324	69	29	73	17
325–349	85	29	82	10
350–374	92	31	93	19
375–399	79	23	81	19
400–424	94	33	96	9
425–449	86	33	86	19
450–474	59	42	59	12
475–499	57	35	57	25
500–524	36	53	38	18
525–549	14	29	14	36
550–574	9	56	7	29
575–599	8	38	8	13
600–624	3	67	2	50
625–649	2	100	2	0
Totals.....	1617*		1610*	

* These totals differ because it was not always possible to examine all the rats for both pregnancy and lactation.

that the farm females attained vaginal perforation at a relatively larger weight than did the city rats. This slower maturity agrees with the situation in the male. These rats, collected in all seasons of the year, show no seasonal closure of the vagina as occurs in adults of some species of rodents.

The relation between weight and pregnancy, and weight and lactation, for city rats is shown in Table 2. Pregnancy was determined by presence of macroscopically visible embryos at autopsy and hence omitted females in the first 5–6 days of pregnancy (Emlen and Davis, 1948). Lactation was determined by

expression of milk from the nipples of dead rats. Few of the females in the city became pregnant until they weighed 200 grams. The correlation coefficient between weight of female and per cent pregnant was +.85. The number of city females lactating was small, but increased with increase in size.

Perry (1946), in England, determined the onset of puberty by histological examination of the ovaries. The presence of corpora lutea was interpreted to indicate maturity. From his data it can be calculated that the weight at which

TABLE 3.—*Relation between weight and presence of placental scars in city rats*

WEIGHT CLASS	PERFORATE FEMALES EXAMINED	PER CENT WITH SCARS
grams		
70- 89	19	0
90-109	19	5
110-129	28	0
130-149	30	0
150-169	29	0
170-189	29	0
190-209	39	3
210-229	24	0
230-249	16	0
250-269	26	8
270-289	35	11
290-309	26	50
310-329	34	47
330-349	25	52
350-369	20	70
370-389	29	55
390-409	26	73
410-429	31	74
430-449	28	86
450-469	8	100
470-489	13	77
490-509	5	80
510-529	7	57
530-549	1	100
550-569	1	100
570-589	3	67
590-609	0	—
610-629	2	100

50 per cent of the rats have corpora lutea is 150 grams. Although Perry does not state the mean weight of his rats, from another table it is clear that few females weighed more than 560 grams.

It is also possible to determine the size at onset of sexual maturity by the presence of placental scars (Davis and Emlen, 1948). Table 3 shows the relation between weight and presence of placental scars in city rats with perforate vaginae. The weight at which 50 per cent of the rats have placental scars is 242 grams.

Summary.—Since the size of rats at sexual maturity may differ from place to

place it is desirable to have such information for use in studies of population dynamics.

The weight at which 50 per cent of the male rats caught on a farm near Baltimore had scrotal testes was 136 grams, and the ratio of 50 per cent point to mean weight was .68. The corresponding weight for rats from the city of Baltimore was 119 grams, and the ratio was .45 (significant difference).

The weight at which 50 per cent of the farm females have perforate vaginae is 88 grams, and the ratio of 50 per cent point to mean weight was .50. The corresponding weight for city rats is 105 grams, and the ratio was .40 (significant difference).

Few city rats became pregnant at less than 200 grams. The weight at which 50 per cent of the city rats have placental scars is 242 grams.

It is concluded that the size at sexual maturity differs in different localities.

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ONE HUNDRED RACCOONS FROM ONE HUNDRED AND TWO ACRES

BY ALLEN REED TWICHELL AND HERBERT H. DILL

Because of a high raccoon population on the Swan Lake National Wildlife Refuge in Chariton County, Missouri, it was believed that raccoons were competing with wood ducks for nesting sites, further, it was believed that some use should be made of the harvestable surplus of these animals. It was decided that a trial removal of 100 raccoons would serve this purpose. The work of removing the raccoons alive was done by personnel of the refuge, the Missouri Conservation Commission, and the Swan Lake Sportsmen's Club. The animals were eartagged and released in an area of more sparse raccoon population.

The animals were taken during a 4½-day period, from January 19 through January 23, 1948. During the period of operation, the temperature ranged from 40°F. to minus 10°F. The last two days afforded sufficient snow for tracking, but tracks of only one raccoon were observed. This animal had traveled approximately 100 yards.

One hundred and two raccoons were taken, but two escaped before they were weighed and sexed. Two of the raccoons were taken in about three hours of

night hunting with dogs. The other 100 animals were taken in daytime tree-climbing operations. Cold weather caused the raccoons to be inactive and tracking with dogs would have been much less efficient.

The success of the project can be accounted for by an unusually high raccoon population and considerable assistance from local raccoon hunters, who did most of the tree-climbing. Neither linemen's pole-climbers nor ladders were used. The hunting party consisted of ten to twenty men; and so it was possible for some of the men in the party to be locating den trees or raccoons while others were capturing those already found.

About half of the raccoons were found in exposed situations where they were seen from the ground. Some of these were in squirrel nests, shallow dens, or on branches. The animals were caught with relative ease by climbing the trees and pushing them from the resting place, or by pulling them out by the tail and hind leg and dropping them to those below, to be caught in nets. Sometimes, by making considerable noise and commotion, the climber could scare the raccoon so that it would jump to the ground.

The nets proved to be very effective. These were made by welding an iron ring about 18 inches in diameter to the tang in a pitchfork handle. A burlap sack was attached to this rim by hog rings. When possible, the raccoons were caught in the net before they hit the ground. Throwing the hoop over them after they were on the ground was difficult, especially if there was considerable underbrush to hamper use of the nets. When it appeared that the raccoon was likely to get away, a dog was released. This always resulted in distracting the raccoon for a few seconds until someone could get a net over it. Animals were transferred to a double burlap sack. Sometimes two or three were put into one sack. None escaped from these double sacks during the few hours before weighing, sexing, and crating. Animals kept in a single sack sometimes got out.

Some of the animals were removed from their dens. Den trees climbed were those that showed the most evidence of raccoon activity, such as scats at the base of the tree, well-scratched bark, or a smooth appearance around the den entrance. In the shallower dens the raccoons were removed by grasping them by a hind foot and the tail and pulling them out. With deeper dens it was often possible to use a forked stick, which was twisted into the animal's hair and skin until it could be drawn within reach. It was not always possible to remove raccoons from their dens.

The entire lot of 100 animals was captured, transported approximately 250 miles, and released without loss, and with only two ninor injuries.

It was calculated, from a map of the refuge, that the area hunted consisted of approximately 102 acres. This comprised some of the best raccoon habitat on the refuge, being mostly a strip of land along both sides of Elk Creek and Yellow Creek. Timber was of all ages, composed chiefly of pin oak, soft maple, and elm, but with a large variety of other species. Acres hunted and catch by days are given in Table 1.

This is believed to indicate the highest harvest of raccoons recorded in literature. Yeager and Rennels (Jour. Wildlife Mgt., 7: 45–60, 1943) record a take

of 42.5 raccoons per square mile at Calhoun Point, Illinois, during the season of 1939–40. Yeager (*Ibid.*, 1:28–36, 1937) records an annual harvest of 8, 9, and 10 raccoons from an 80-acre tract in Mississippi. Both of these studies differ from the present study in that they were made on areas where there was an annual raccoon harvest, while the Swan Lake area had been closed to all hunting and trapping for the past ten years. Furthermore, the 102 acres of the Swan Lake area are all good raccoon habitat, while this was probably not true of the other two areas, especially the Mississippi area. It is the estimate of the Conservation Commission and refuge personnel who participated in the job that only about 60 per cent of the raccoons on the hunted area were taken.

The 100 raccoons on which data were taken consisted of 40 males and 60 females. This sex ratio of 67 males per 100 females is considerably different from that shown by data obtained from over ten thousand raccoons taken by hunters and trappers in Missouri in both 1940 and 1941. In 1941, a ratio of 170 males per

TABLE 1.—*Acres hunted and raccoons caught at Swan Lake Refuge, Missouri*

DATE 1948	ACRES HUNTED	RACCOON CATCH
January 19	10*	13 (including 2 taken at night)
January 20	20	22
January 21	32	41 (including 2 that later escaped)
January 22	15	19
January 23	25	7
Totals	102	102

* Does not include acreage covered in night hunting.

100 females was found. In 1940, hunters took 159 males per 100 females, and trappers took 144 males per 100 females. Possibly the Swan Lake sample is too small to be applicable to state-wide conditions or even to those on the refuge alone. Some of the difference may be accounted for by the fact that the area had been closed to hunting for many years. However, it is believed that the method by which raccoons were taken for restocking was less selective than either regular night hunting or trapping.

The 40 males ranged in weight from 8.0 pounds to 20.8 pounds, averaging 13.0 pounds, with a median weight of 12.2 pounds. Females ranged in weight from 6.8 pounds to 15.7 pounds, averaging 11.1 pounds, with the median weight being the same as the average. There was no large break in the weights of either males or females that would indicate a significant size difference between young and mature animals.

Thirty-two of the animals taken were found alone. Two raccoons were taken from each of twelve trees, three from each of six trees, four, five, and six raccoons from one tree each. Data on eleven animals are not available, but it is known that they are from fourteen raccoons found in groups of two, three, four, and five each.

Although it is felt that the age of a raccoon can not be definitely ascertained by weight, it appeared that those found in one tree did not necessarily include a family group. Six raccoons taken from one tree included two large males, 19.5 pounds each (only two larger raccoons were taken during the entire operation, and so it is assumed that these two were adult), and four females, weighing 10.4, 10.9, 11.6, and 11.9 pounds, respectively, none of which can be definitely classed as either old or young. Five females, weighing 8.0, 11.0, 11.5, 12.0, and 14.9 pounds, respectively, were taken from another tree. There was at least one young and one adult, with the other three of undetermined age. At least four other raccoons were in this tree, but it was not possible to capture them.

The heaviest male, 20.8 pounds, was denning with another male of 12.6 pounds. The second heaviest male, 20.0 pounds, was denning with two other males, 15.1 and 16.1 pounds, presumably all adult; there were three other raccoons in the same den, but these were not taken. One female, weighing 12.8 pounds, was observed to have an enlarged vulva. With her was a male weighing 16.8 pounds.

Of the forty males, the fourteen of lightest weight were all denning with other raccoons. Only eight of the forty males were found alone. Thirty-two of the sixty females were alone. These included the female of lightest weight (probably young) and the three of heaviest weight (probably adult). Eleven of the sixteen heaviest females were found alone.

Missouri Conservation Commission, Columbia, and U. S. Fish and Wildlife Service, Sumner, Missouri. Received April 2, 1948.

SUMMER POPULATIONS AND MOVEMENTS OF THE COTTON RAT AND OTHER RODENTS ON THE SAVANNAH RIVER REFUGE

By Arnold B. Erickson

During extensive investigations at Savannah, Georgia, on the effects of DDT application on wild life, opportunity was afforded to make observations on rodent ecology, numbers, and movements, as determined by trapping and tagging studies of the cotton rat (*Sigmodon*) and other rodents. These observations covered the period May 1 to September 6, 1946. Negative effects of DDT applications on rodents have already been reported elsewhere (Erickson, U. S. Pub. Health Repts., 62: 1254–1262, 1947). The U. S. Public Health Service and the U. S. Fish and Wildlife Service cooperated in these investigations.

Field methods.—The Savannah River Refuge consists of 12,000 acres of marsh and upland lying along the Savannah River seventeen miles from the sea. Trapping was confined to 30.6 acres of small islands (hammocks) and dykes near the refuge headquarters.

Numbered stakes were set out on the islands in rows 100 feet apart with 100 feet between stakes in each row. One row of stakes was also placed on one side of each dyke with 100-foot intervals between the stakes. One trap was set at each island stake; at each dyke stake a second trap was set immediately across the dyke (30 feet) from the first trap at the stake.

The islands varied in size from one acre to six acres and the dykes connecting them from 218 feet to 1437 feet long. Thirty feet was the average width of the dyke top from water level to water level, and an automobile track traversed each dyke.

TABLE 1.—*Summary of statistics pertaining to retrapped cotton rats*

TAG NUMBER	DATE TRAPPED	DATES RETRAPPED	FEET TRAVELED	SEX	AGE FIRST TRAPPED
9	5/28	5/29,30	0	male	adult
10	5/28	7/10	130	male	immature
14	5/29	5/30; 7/3,4	100	male	adult
22	5/30	7/9	100	female	immature
26	6/4	7/5	0	female	adult
28	6/4	6/5	30	male	adult
29	6/4	6/6	100	female	adult
37	6/5	7/3	100	female	adult
43	6/6	8/7	0	female	adult
49	6/11	6/12,13,14	100	male	immature
53	6/12	6/14	0	male	adult
55	6/12	6/14	0	male	immature
58	6/13	7/16	100	male	adult
62	6/19	6/21	0	male	immature
65	6/26	6/27,28	200	male	immature
69	6/27	6/28	200	male	immature
72	7/2	7/4	30	male	immature
75	7/2	7/4,5	130	male	immature
78	7/2	7/4	0	male	immature
81	7/2	7/4	0	male	immature
82	7/2	8/15	30	female	adult
84	7/3	7/4; 8/6,7,9	30	female	adult
90	7/4	8/9	100	female	adult
92	7/4	7/5	0	female	adult
94	7/4	7/5,9,10	130	male	immature
96	7/5	8/8,23	130	female	adult
98	7/9	7/11	130	female	adult
104	7/10	8/14	200	male	adult
107	7/12	8/9	0	female	immature
116	7/23	8/30	0	female	adult
119	7/23	7/24	100	female	adult
120	7/23	8/30	0	male	adult
121	7/23	8/7*	0	male	immature
128	7/30	8/2	100	male	immature
142	8/8	8/29	30	female	adult
143	8/14	8/20	100	male	immature
153	8/20	8/22	0	male	immature
173	9/5	9/6	0	male	adult

* Killed by a truck on this date.

Two types of live traps were used for sampling rat and mouse populations—the Sherman metal trap and a fiber-board modification of it. The fiber-board model is a poor substitute for the all metal trap. Its chief faults are the inadequacy of its trigger-release mechanism and swelling of the back panel when the trap

PLATE 1

UPPER: Dyke-marsh trapping area. Marsh is dominated by cut-grass (*Zizaniopsis miliaceae*), a favorite habitat of cotton rats.

LOWER: Island with mature live oak and water oak. House mice were most common here.

becomes wet. A swollen panel makes it difficult to open the trap for releasing animals or for cleaning. About 75 per cent of the trapping was accomplished with the metal traps. Fifty were used each week from May 1 to September 6. An additional fifty fiber-board traps augmented this number, beginning July 29.

Traps were rotated around the area so that each island and dyke was retrapped every fourth week up to July 29, and every second week after this date. The trap-week was four nights. The islands were subject to trapping at the rate of eighty-five trap-nights per acre and the dykes subject to a rate of 385 trap-nights per acre.

Table 1 shows that even with the addition of fifty fiber traps to the metal traps already in use on July 29, the catch did not increase suddenly. Very few cotton rats, in fact, were taken in the fiber traps. Rats from both types of traps were transferred to a multiple type holder (Erickson, Jour. Wildlife Mgt., 11:351, 1947) for tagging.

Rats and mice were marked by toe clipping during the first week of trapping. After May 7 all animals were tagged in the left ear with numbered Monel metal fingerling tags. These served their purpose admirably. One of thirty-eight retrapped cotton rats showed ear infection due to the tag.

Only two baits, rolled oats and chick mash, were used consistently. Ants cleaned up most other baits.

Vegetational types.—The islands, dykes, and the marsh surrounding them formed three ecological types. The islands (live oak forest) with their mature trees (Pl. I) and understory of vines and shrubs are at present the climax stage. Climax trees are live oak (*Quercus virginiana*), sweet gum (*Liquidambar Styraciflus*), pignut hickory (*Hicoria glabra*), and hackberry (*Celtis laevigata*).

The dykes (raspberry, silverling, tallow tree shrubs) are an intermediate stage between the climax and the marsh which is a wide-spread early seral stage dominated by cut-grass (*Zizaniopsis miliacea*). Dominant trees of the dykes are Chinaberry (*Melia Azedarach*), Chinese tallow tree (*Sapium sebiferum*), and black willow (*Salix nigra*). Dominant shrubs of the islands and dykes include dwarf palmetto (*Sabal minor*), bayberry (*Myrica cerifera*), blackberry (*Rubus* sp.,), yaupon (*Ilex vomatoria*), French mulberry (*Callicarpa americana*), button bush (*Cephalanthus occidentalis*), and silverling (*Baccharis halimifolia*). The most important herbaceous species on the dyke and island edges was cut-grass.

Cotton rat.—Cotton rats (*Sigmodon hispidus hispidus*) were trapped more commonly along the dykes and around the island edges than in the interior of the islands. Apparently they preferred the edge between the marsh and the upland. From May 1 to September 6, 158 were taken in 4877 trap-nights on 30.6 acres of islands and dykes. One hundred fourteen were trapped on 7.6 acres of dyke in 2929 trap-nights and forty-four on 23 acres of islands in 1948 trap-nights.

Thirty-eight cotton rats (24 per cent) were retrapped one or more times. Thirty-one were retaken once; four, twice; three, three times; and one, four times. Twenty-four were retaken the week of tagging; two, the first week after tagging; one, the second week after; one, the third week after; two, the fourth week after;

nine, the fifth week after; three, the sixth week after; and one, the ninth week after. (The number retaken after tagging is greater than thirty-eight because some of the rats were retaken the week of tagging and again in subsequent weeks.) The data on tagging, retrapp' g, and distance traveled are summarized in Table 1.

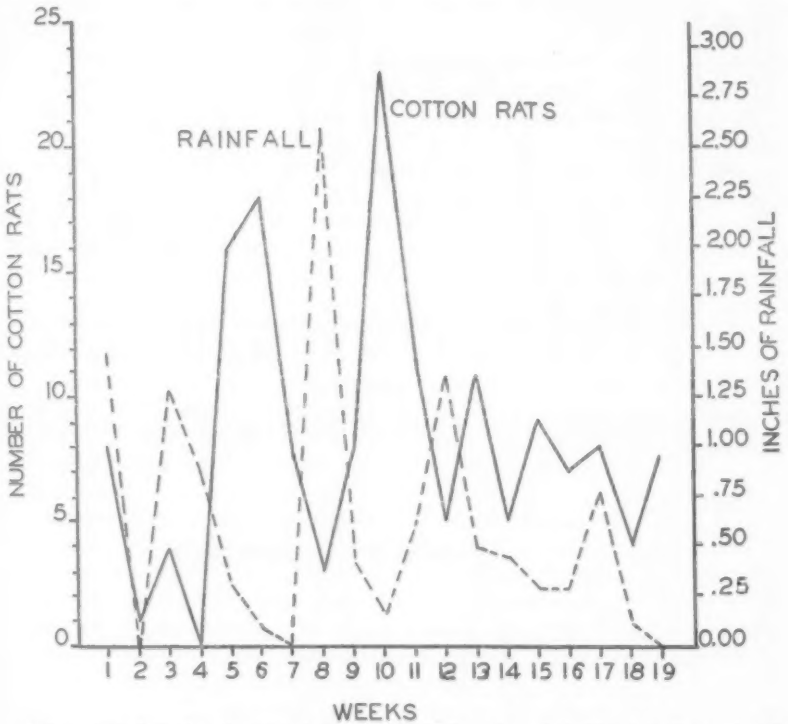

FIG. 1—Number of cotton rats trapped over a 19-week period, May 1 to September 6, and rainfall in inches for the same period. Trapping and rainfall data are based on weekly periods consisting of four days and nights. Fifty traps were used the first 12 weeks of trapping and 100 traps the last 7 weeks.

Divided according to sex, 84 males, 68 females, and six of undetermined sex were trapped; according to age, 85 adults, 71 immatures, and three of unknown age were taken. The 10.4 per cent greater catch of males than females and also the 21 per cent greater retrapping of males (Table 1 and Fig. 2) supports the idea that male cotton rats, like the males of certain other rodents, have a greater tendency to wander than do females. The average distance traveled by twenty-three retrapped male cotton rats was 67 feet and by fifteen females, 56 feet. Seventeen immature rats averaged 71.7 feet of movement and twenty adults, 59 feet.

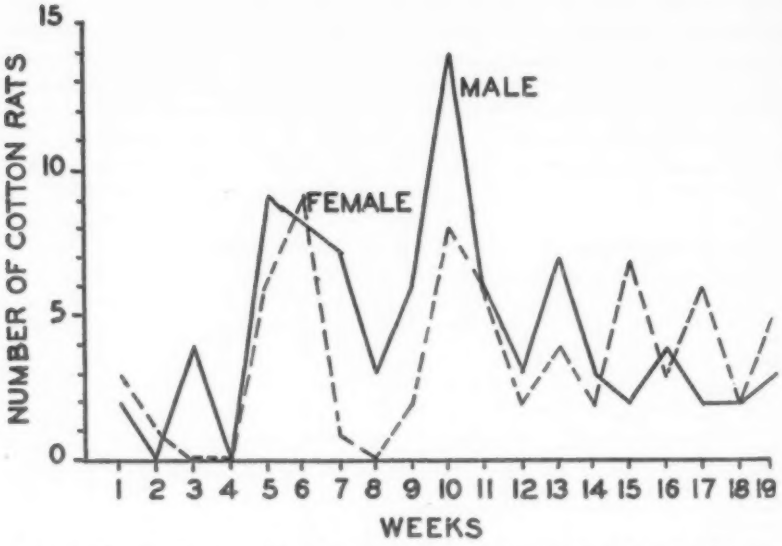

FIG. 2—Number of male and female cotton rats trapped over a 19-week period, May 1 to September 6.

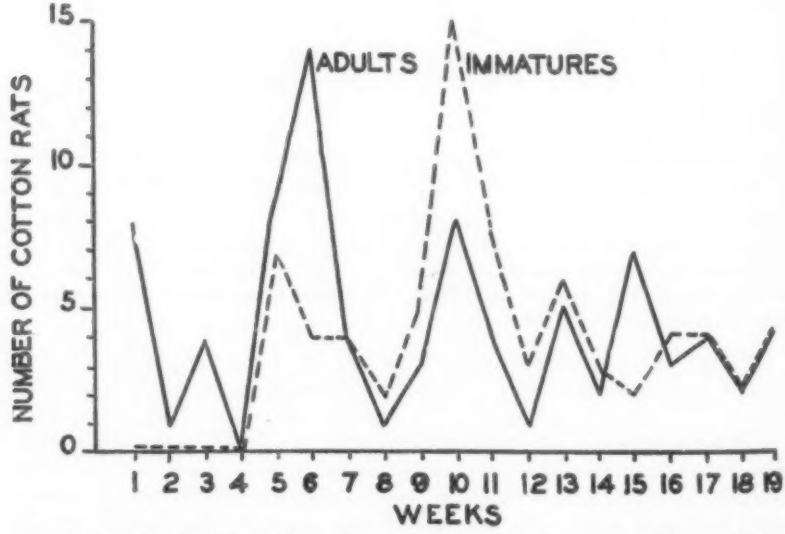

FIG. 3—Number of adult and immature cotton rats trapped over a 19-week period, May 1 to September 6.

Figure 1 also shows the number of rats trapped over the 19-week period. Peak catches, composed of many adult females and immature rats (Fig. 3), came in mid-June and again in mid-July. A careful study of the weather data for this period, supplied by the Savannah Weather Bureau, showed that, in general, few rats were caught during weeks of abundant rainfall and that the largest catches were made during weeks of little rain (Fig. 1). Temperature and relative humidity seemed not to influence the catch.

Cotton rat populations in the South are cyclic, but with irregular periodicity. At Athens, Georgia, Odum (Oriole, 12: 48–49, 1947) has trapped quadrats each fall and winter for several years. December to February, 1946–47, was one of the highest periods in abundance of cotton rats recorded—80 to 100 per acre in one field. A "crash" came in the spring of 1947. Komarek, in south Georgia, also found high populations in the fall and winter of 1946–47. Apparently peak populations were widespread in the state during this period.

House mouse.—Feral house mice (*Mus musculus*) came to the traps more frequently than any other rodent except the cotton rat. House mice probably became established on the refuge islands years ago when the first slave huts were built. Remains of these huts, household implements, and gravestones still recall the rice-growing era.

Eighteen house mice were trapped in 4877 trap-nights. They showed a definite preference for the islands—fourteen were trapped there. Seven (38.8 per cent) were retrapped one or more times. Six were retrapped the week of tagging (usually the night after); one the tenth week after; and one the fourteenth week after.

House mice were greater wanderers than the cotton rats. Only four were taken at the site of original capture. Number 3, an adult male, was retrapped 600 feet and fourteen weeks after the first trapping, traveling during the interval from one island to another along a dyke. Number 52, another adult male, traveled about 400 feet in two days. Number 59, an adult female, was retaken 200 feet from the original trap site ten weeks after the first trapping. An adult male, number 101, got the trap habit and was retaken five times between July 10 and August 1. He also was a wanderer visiting four different trap sites. Taken first on a dyke, he moved 300 feet to an island. Not satisfied there, he traveled 1900 feet to another dyke. From the site of his first trapping to his last he wandered 2200 feet.

Eleven of the house mice were males, four were females, and three of unknown sex. Five of the males and three of the females were retrapped. All but two of the eighteen animals were adults.

Wood rat.—Only eight wood rats (*Neotoma floridana floridana*) were taken, a few each month from May to September, in 4877 trap-nights. Only two immature animals were retrapped. Two days elapsed between the first and second capture for each, and each had moved 100 feet. All in all, seven males, one female, six young, and two adults were trapped.

Rice rat.—From May 1 to September 6, only four adult male rice rats (*Oryzomys palustris palustris*) were trapped in 4877 trap-nights, the first on May 2 and the

last on May 28. None was retrapped. During the six-week period, March 18 to April 30, immediately preceding the tagging study, fifteen were trapped for parasite examination on other parts of the refuge in 1045 trap-nights. The areas trapped after May 1 were similar to those trapped before this date, yet only four rice rats were taken in May and none in June, July, August, or September. It seems possible that the movements of rice rats may be affected by high summer temperatures and that a partial aestivation occurs. However, I have found no report in the literature on aestivation of rice rats.

Cotton mouse.—Only two cotton mice (*Peromyscus gossypinus gossypinus*) were taken during the tagging study. One trapped on May 24 was retrapped on July 30, 135 feet from the point of first capture. Its ear was infected and superating due to the tag.

Six cotton mice were trapped on 1045 trap-nights for parasite examination before May 1.

Acknowledgments.—I wish to thank Mr. Wm. P. Baldwin, of the U. S. Fish and Wildlife Service for assistance in identifying certain plants, and Mr. Harold Kluber for assistance with the trapping and tagging. Dr. Eugene P. Odum read the manuscript and offered helpful suggestions. Dr. S. W. Simmons, Chief of the Technical Development Division, Communicable Disease Center, made this research possible.

Summary.—From May 1 to September 6, 1946, 158 cotton rats were trapped on 30.6 acres of islands and dykes of the Savannah River Refuge, South Carolina, in 4877 trap-nights. Cotton rats were obtained more commonly along the dykes and around the island edges than in the interior of the forested islands. Only twenty-three individuals were caught per 1000 trap-nights on the islands whereas thirty-eight were caught per 1000 trap-nights on the dykes. Moreover, most of those taken on the islands were caught at the edges. The cotton rats were tagged with Monel metal ear tags. Thirty-eight of them (24 per cent) were retrapped one or more times. The interval between trapping and retrapping varied from one day to nine weeks. Divided according to sex, 84 male and 68 female cotton rats were trapped; according to age, 85 adults and 71 immatures. The 10 per cent greater catch of males than females and the 21 per cent greater retrapping of males suggests that males are greater wanderers. Peak catches of cotton rats came in mid-June and mid-July. The largest catches were made during weeks of little rain; few rats were caught during weeks of abundant rain. Temperature and relative humidity seemed not to influence the catch.

Eighteen house mice were trapped in 4877 trap-nights. Seven (38.8 per cent) were retrapped one or more times from the first day after tagging to the fourteenth week after. The mice did considerable wandering. One male was trapped 600 feet from the original site of capture and another moved 2200 feet.

Only eight wood rats, four rice rats, and two cotton mice were trapped in the 4877 trap-night period.

Minnesota Division of Game and Fish, 1005 Commerce Bldg., St. Paul 1, Minn. *Received February 6, 1948.*

A *SIGMODON* AND *BAIOMYS* POPULATION IN UNGRAZED AND UNBURNED TEXAS PRAIRIE

By Lucille F. Stickel and William H. Stickel

A brief small-mammal population study was made incidental to other work at Camp Bullis, Texas, in August, 1947. The study, although incomplete in some respects, gave information on the numbers and movements of *Sigmodon* (cotton rats) and *Baiomys* in an area of ungrazed and unburned tall-grass prairie. Vegetation of this type was formerly common in Central Texas, but is now rare because of grazing and cultivation.

Few population studies of *Sigmodon* or *Baiomys* have been published. Stoddard (1932), whose work was done in the southeast, gives the only estimate of a *Sigmodon* population that we have been able to find. He states that "Approximately 40 rats to the acre were caught in a carefully planned rat-population experiment carried on in a typical broomsedge area in 1926." The method of study is not mentioned. This estimate may be too large, for with methods generally used in 1926 many rats that normally lived outside the study area would be caught in the area and counted as residents. The same difficulty, greatly exaggerated, is encountered in records of hundreds of rats being caught or poisoned in a single small area. Such reports demonstrate the abundance of cotton rats, but give little evidence about the actual populations.

Many authors have discussed the habits and habitat of *Sigmodon*. They stress its preference for heavy cover, particularly in the form of matted broomsedge. Stoddard (1932) gives a good account of the cotton rat, with emphasis on its influence on quail populations and methods of control.

Baiomys appears to have received little field study. Bailey (1905) briefly discusses the animal's ecology, and Blair (1941) gives an excellent account of the biology of captive *Baiomys*. Writers are in general agreement that *Baiomys*, like *Sigmodon*, is fond of matted grass cover, although both may be found in other habitats.

DESCRIPTION OF AREA

Camp Bullis is a 30,500-acre military reservation in Bexar County, about eighteen miles northwest of San Antonio. The camp lies entirely on the Balcones Escarpment, a wide zone of rather barren limestone hills and fertile valleys. The Escarpment is the eroded border between the Edwards Plateau and the Rio Grande Plain. Faunistically, Camp Bullis more nearly resembles the Plateau than it does the coastal plain.

Camp Bullis was protected from grazing from 1918 until the fall of 1947. Much of the camp was purposely burned each year prior to the recent war, and parts were again burned late in the winter of 1946–47. The valleys support tall-grass prairie with scattered clumps of oak, elm, hackberry, and other woody plants. About 70 per cent of the area of the valleys is covered with grass. Little bluestem, *Andropogon scoparius*, is dominant in general. Johnson grass, *Sorghum halepense*, and various genera of needle-leaved grasses are locally dominant.

Buffalo grass, grama grasses, and other short grasses are dominant only in patches. In this locality tall-grass prairie is a subclimax. The true climax, at least in the valleys, is deciduous forest.

Deer are abundant. Jack rabbits, cottontails, armadillos, and raccoons are common. Predatory species of birds and mammals are scarce, probably because of the low availability of rodents. The rarity of small mammals in most parts of Camp Bullis has been noted by Hamilton and Brennan (Brennan, 1945). Brennan states that "A thorough survey of supposedly suitable areas revealed no evidence of small rodents," and, "The present scarcity of small rodents on this area might be attributable to a low in their population cycle, were it not for the absolute absence of old sign."

The scarcity of rodents on the reservation was demonstrated in our preliminary trapping. Fifty traps were set in grassland, tree clumps, and amongst rocks. The areas trapped had been burned over the previous winter, but had good stands of tall grasses, trees, and bushes. In three nights, 150 trap-nights, only two animals were caught, one *Sigmodon hispidus* and one *Peromyscus pectoralis*.

The few prairie areas which had not been burned for several years looked much like the burned prairie and had practically the same vegetation, but differed significantly in having a grass mat. The dead grass remaining from previous years formed a canopy in many spots. In burned prairie the dead grass was absent, exposing the dry, crumbling earth between the clumps. The dry grass mat in the unburned prairie provides good small-mammal cover and no doubt retards evaporation, making a moister, cooler environment. An area of this type was chosen for quadrat trapping.

STUDY PLOT

The study plot was in the Salado Valley, about 100 yards west of the dry bed of Salado Creek. The trapping area was a 6.1-acre rectangle of unburned and ungrazed prairie approximately 344 feet wide and 774 feet long. The study area was continuous with similar prairie on three sides. A narrow end of the plot was near a road. Across the road was extensive grassland that had been burned the previous winter. There was no water and no moist area near the plot. The dominant grasses were little bluestem and Johnson grass, but needle-leaved grasses predominated locally. The grass varied from one to four feet in height. There were broken stands of trees on the prairie within a few hundred feet in any direction. There were a few small trees along part of one side of the study plot, and just within the other side were two large trees, each with an understory of weeds and brush. *Sigmodon* and *Baiomys* were not the only mammals using the study plot. Trails or droppings of armadillo, rabbit, deer, and raccoon were noted, and one male *Reithrodontomys fulvescens* was trapped within the area.

TRAPPING

The area was trapped for nine nights, August 3–12, 1947. Sherman live traps (rat-size) were baited with rolled oats and peanut butter. Traps were closed in early morning and reset in late afternoon. Animals were marked and released at the place of capture. During the first six nights, fifty traps were

used. They were placed in ten rows of five traps each, with traps at 86-foot intervals. During the last three nights of trapping there were ninety traps in use. The forty additional traps were set between the original traps on the short rows. In this new arrangement there were ten rows of nine traps each, with the traps forty-three feet apart in the row and the rows eighty-six feet apart. This spacing was largely the result of convenience. The traps might well have been closer together, at least in the second period. Nevertheless, the trapping plan proved to have certain advantages. The wider trap spacing of the first period, and the distance between lines in the second period, allowed more freedom of animal movement and so increased reliability of travel records. The closer spacing and more numerous traps of the second period probably resulted in a more nearly complete trapping of the population, and gave more captures per individual than would have been possible in the same length of time with fewer traps.

SIGMODON HISPIDUS

Eighty-three cotton rats were collected in the nine nights. An approximate measurement of head-body length of each rat was taken in the field. Sex, breeding condition, and apparent age were recorded. Adult animals were easily sep-

TABLE 1.—*Grouping of Sigmodon from field records*

CLASS	NUMBER	SIZE
Adults	36 (17 males, 18 females, 1 undet.)	Exceptionally large animals, all mature and approximately the same size
Subadults	13 (6 males, 7 females)	Not full adult size; in breeding condition or not
Juveniles	24 (15 males, 9 females)	Intermediate in size, not in breeding condition
Young	10 (4 males, 6 females)	Small animals, probably recently emerged from nests

arated from others, but the smaller rats did not fall into sharply defined groups. They were probably from litters born at many different times during the season (Table 1). The trend in number of captures was regularly upward except for August 7 and 8 (Table 3). The reason for the pronounced drop on these two days is unknown.

Travels.—Fifty cotton rats were captured at least twice each, some being retaken in the same trap and others in different traps. Distances traveled did not seem to be correlated with number of captures or with time between captures. Ten adult males and all juvenile males had travel records of less than 200 feet. Two adult males moved more than 200 feet (one 242 feet, the other 279 feet). The maximum distance recorded for a female cotton rat was 94 feet. Table 2 summarizes the greatest distance between capture points for each individual.

The data indicate that in this environment the normal range of female cotton

rats is less than 100 feet in diameter. The average range of males probably is less than 200 feet. The two longer travels by males presumably represent occasional wanderings.

Population size.—Eighty-three *Sigmodon* were collected (42 males, 40 females, 1 undetermined). This was probably close to the actual number of animals using the area, for there was a regular upward trend of repeats in the daily collections, with 32 repeats and only 4 new animals on the final day of trapping.

The total number caught was checked by use of the collection ratio, or Lincoln Index. This ratio was used by Raevskii (1937) in small mammal studies,

TABLE 2.—*Travels of recaptured Sigmodon*

DISTANCE (FEET)	MALES: ALL AGES	FEMALES: ALL AGES	MALES: ADULTS	FEMALES: ADULTS
0	8	12	1	5
43	6	4	1	3
86–100	6	6	4	4
101–150	2	0	1	0
151–200	4	0	3	0
201–250	1	0	1	0
251–300	1	0	1	0

and previously by others in studies of other kinds of animals. The relationship is expressed by the equation:

$$\frac{\text{Number of animals using the area}}{\text{Number collected 1st night}} = \frac{\text{Number collected 2nd night}}{\text{Repeats collected 2nd night}}$$

The collections of August 9 through 12 were large enough for use in this way. Twenty-two *Sigmodon* were collected on the 9th. Twenty-four were collected on the 10th; six of them were animals also collected on the 9th. Using these data in the equation, the number of animals using the area is estimated to be 88. The same procedure comparing the 10th with the 11th gives the relationship, x:24::33:9, and x = 88. Comparison of August 11 and 12 gives, x:33::36:16, and x = 74. An average of these three estimates is 83.

The number of *Sigmodon* per acre can be estimated best by the method proposed by Dice (1938). A strip one-half the width of the average home range is added to the borders of the trapped plot for calculations. The method of allowing a buffer strip within the trapped plot (L. F. Stickel, 1946) makes it necessary to discard data from marginal traps. The *Sigmodon* plot was too narrow to make this advisable.

The average range of *Sigmodon* was not known precisely, but was apparently 200 feet or less for males and 100 feet or less for females (see above). The population per acre was calculated by using minimal and maximal estimates of the average size of the home range. These were decided upon by study of the movement data (Table 2). The use of maximal and minimal range is of value when the actual size of the average home range is not known exactly, for it makes it possible to arrive at reliable limits between which the true per acre figure should

lie. The better the size of the range is known, the narrower the limits become. For this reason, as well as others, the range size should be determined for each time and place, for it is ecologically variable, not constant for the species.

The minimal and maximal average range sizes used for female cotton rats were 50 and 100 feet. For males they were 100 and 200 feet. Calculated on these bases there were 5.4 to 5.9 females and 4.8 to 5.7 males per acre. It is estimated, therefore, that there were 10 to 12 cotton rats per acre.

BAIOMYS TAYLORI

Forty-five *Baiomys* were trapped (24 females, 20 males and 1 undetermined). They were all about the same size, appearing to be adult and subadult animals. In addition, a completely albino adult male was caught by hand near a corner of the study plot.

TABLE 3.—*Daily captures of Baiomys and Sigmodon*

DATE	BAIOMYS			SIGMODON		
August, 1947	New	Repeat	Total	New	Repeat	Total
4	3	0	3	10	0	10
5	5	1	6	12	1	13
6	8	1	9	12	5	17
7	4	3	7	2	1	3
8	1	6	7	4	5	9
9	0	6	6	11	11	22
10	13	7	20	11	13	24
11	4	5	9	17	16	33
12	6	6	12	4	32	36

Travels.—Twenty-one *Baiomys*, 11 males and 10 females, were trapped at least twice each. Eight of the recaptured males were taken in the same trap each time. The other three were taken in traps 43 feet apart. Seven of the recaptured females were taken in the same trap each time, but three were taken in traps 86 feet apart. It is highly probable that the normal *Baiomys* range in this habitat is less than 100 feet for both sexes.

Population size.—The daily trend of new and repeat *Baiomys* (Table 3) contains marked irregularities that complicate estimating the population size. At first the trend was regular. On August 8, six repeats were taken, and only one new animal. On the ninth, all six captures were repeats. It seemed that most of the available animals had been collected. But on the morning of the tenth, thirteen new animals (5 males, 8 females) and seven repeats were found in the traps. Several possible explanations were considered. The new mice may have come from outside areas and settled in the study plot, or they may have been in the study plot all the time in aestivation. The heat and severe drouth make the latter a possibility. A heavy rain of 0.54 inch fell on the evening of the tenth. The impending weather change may have encouraged the movement, whatever the source of the animals.

It was thought that the new mice might be transients. However, four of the thirteen (31 per cent) were re-taken during the next two days For comparison, four out of seven mice (57 per cent) collected on the 8th were re-taken on the 9th or 10th. Thus it does not seem likely that all of the new mice were transients. It is not proven, however, for transient animals have been known to pause a day or more in areas outside their normal ranges.

The captures were tabulated according to traps to see if the increase in unmarked animals was caused by the new traps that were set in the area on the 9th. It was thought that some mice might range between traps and not be captured when the traps were 86 feet apart. Tabulation showed that only four of the thirteen new mice were taken in new traps. The other nine were taken in seven of the original traps, as there were two double captures. These seven traps had been available previously; one had been empty six nights, one on four nights, four on three nights, and one on two nights. It would seem logical to conclude that the presence of traps at new sites was not a major factor in the increase of unmarked animals, and that the original trap spacing provided traps in the ranges of most individuals. On the other hand, the impending weather change may have caused resident mice to travel more widely on the night of the ninth than they had before. If this occurred, it is evident that traps had not previously been available in the ranges of all individuals. There may also have been some *Baiomys* that lived between the lines of traps and were never caught.

The size of the population was computed as for *Sigmodon*. Records from August 9 through 12 gave estimates, for the number of *Baiomys* using the area, of 40, 60, and 54, an average of 51. This exceeded the actual catch of 45 animals, and is thus in accord with the fact that several new animals were collected even on the final day of trapping.

The calculated total (51) was translated to per acre figures by using minimal and maximal average home ranges of 25 and 100 feet. The results were 7.9 and 6.9 per acre. Thus, the population was estimated from records of the last four days to be between six and eight per acre. The estimate would be about half this large if the data for the first six days were considered alone.

RUNWAYS

From the apparent sign we would not have guessed the presence of a tenth of the population that was actually using the habitat. Here and there we could trace portions of what appeared to be old, unused runways for a few feet before they faded out, but in general they could not be found. The average runway of *Microtus pennsylvanicus* is like a paved highway in comparison with the barely suggested trails of Camp Bullis *Sigmodon*. The rats probably move about under the tussocks as well as between them. A more or less circular opening around the base of each grass clump is formed by the dead lower leaves arching up and out before sagging to the ground. A *Sigmodon* was found in a cavity of this type and others were trapped in them. The rodents travel through these hidden openings and may be partly responsible for them, but signs of use are seldom detectable.

Authors discussing the habits of cotton rats in the southeastern states, eastern

Texas, Oklahoma, and New Mexico, seldom fail to mention the numerous, long, well-defined, *Microtus*-like runways. Well-marked runways are made even where the vegetation is so thin that beaten paths are not needed for easy travel. Harper (1927), speaking of the Okefinokee Swamp region, says, "In the 'sand scrub' the rats maintained well-defined trails even where the surface of the ground was open and sandy, without grass or other obstruction to progress in almost any direction." The same impression is gained from Hamilton's remark (1943) that, ". . . where the cover is thin these highways can be seen for some distance." More in agreement with our observations are the comments of Jameson (1947), who worked chiefly in grassland at Lawrence, Kansas. After describing the definite paths of *Microtus ochrogaster* he states, "Cotton rats, on the other hand, apparently do not use their runs over long periods, for they are not well-beaten runways, but are made merely by parting the grass and not by trampling it down or cutting it off."

It does not appear from these references that the local or regional differences in runway formation are governed by the density of the vegetation at any one site. Possibly they represent an adjustment of the animal's habits to the average habitat condition in a general area.

DISTRIBUTION OF SPECIES IN THE PLOT

The trapping records indicate that there was some segregation of *Sigmodon* and *Baiomys* in the study area. Cotton rats were well distributed over the plot, except that few were taken in the twenty traps of the northwest corner. These traps (22 per cent of the number set) caught twenty-two of the forty-five *Baiomys*. No *Baiomys* were taken in the sixteen traps in the adjacent southwestern corner of the plot. The other twenty-three *Baiomys* were caught in various parts of the area. Eighteen traps caught both species, fourteen caught only *Baiomys*, and forty-one caught only *Sigmodon*. Ecological correlations of this partial segregation were not apparent. The segregation was far from complete, for both species were frequently caught in the same trap on succeeding nights.

DISCUSSION

The unburned prairie in which trapping was done had essentially the same type and amount of vegetation as nearby burned prairie, but had much higher rodent populations. The only observed factor that could account for this difference was the presence of abundant, matted dead grass in the unburned grassland. This grass mat provided good cover for small mammals and may also have been beneficial by reducing ground temperatures and retarding evaporation. Stoddard (1932) pointed out that cotton rats are so dependent on heavy grass cover that they can be controlled satisfactorily by periodic removal of the grass mat by burning. Baker (1940) found that on the coastal prairie of Texas both grazing and burning severely reduced the numbers of *Baiomys*, *Sigmodon*, and other rodents. Phillips (1936) demonstrated that in the tall-grass prairie of Central Oklahoma *Sigmodon* was almost entirely restricted to undisturbed areas and was absent where there was any grazing.

It is evident that the absence of the grass mat is one of the factors responsible

for the very low populations of small mammals that characterize not only Camp Bullis, but large areas of the Edwards Plateau and the Balcones Escarpment. Buechner (1944) has shown that much of the eastern section of the Edwards Plateau was covered with dense stands of little bluestem until less than a century ago. Occasional fires set by Indians and natural causes helped keep down woody vegetation, and the grass mat formed by the tall grasses between burns tended to shade out the seedlings of woody plants. Grass-loving rodents such as *Sigmodon* were probably common in this habitat.

Heavy grazing soon restricted the tall-grass stage of succession to protected spots. The succession was usually set back to the second stage (short grass) or the third stage (three-awn grasses), but the weed and bare ground stages appeared all too commonly (Buechner 1944). On most ranches livestock keep palatable grasses clipped close to the ground, often closer than an average lawn is cut. The grass mat is, of course, completely gone wherever grazing occurs. In addition, the amount of grassland is greatly reduced by heavy growths of oaks and juniper. Brush and scrubby woodland have taken over vast areas since grazing succeeded occasional burning as the determining factor in the environment. The situation is obviously unfavorable to the rodents that were probably the commonest types in earlier days. Few if any small herbivores beside the jack rabbit seem to have benefited by the change.

The elimination of the grass mat does not explain the rarity of rodents that require other ecological niches. A factor that prevents larger populations of fossorial rodents in this area is the nature of the soil. Some burrowing rodents flourish on overgrazed land if the soil is light, but few prefer heavy soils. The soil at Camp Bullis, and on much of the Edwards Plateau, is a very dark, stony clay of the Valera series. It is derived from the prevailing Cretaceous limestone, fragments or outcrops of which are abundant in the clay at most points. On the dry surface of the earth the clay is in minute, loose particles. Below the loose surface the slightly moist clay is nearly as firm and tough as dry chewing gum. The prohibitive difficulty of burrowing in such a soil may well account for the rarity of fossorial rodents. We saw none of them at Camp Bullis. Brennan (1945) lists *Citellus mexicanus* as scarce, limited, and *C. variegatus* as scarce. Geomyids and heteromyids, most of which prefer loose soils, have not even been recorded from Camp Bullis.

SUMMARY

A 6.1-acre rectangle in ungrazed and unburned tall-grass prairie at Camp Bullis, Bexar County, Texas, was live-trapped from August 4 through 12, 1947.

The home range of *Sigmodon hispidus* in this habitat was less than 100 feet in diameter for females, and less than 200 feet for males. Greater travels were recorded only for two males.

The home range of *Baiomys taylori* was less than 100 feet in diameter for both sexes. None was taken in traps more than 86 feet apart.

The population size was calculated by using the collection ratio to estimate the total number using the area. This total was converted to per acre figures by

treating it as the population of the study area plus an area around it equal in width to one-half home range diameter. For this purpose, minimal and maximal estimates of the home range size were used. The resulting figures provide limits between which the true number per acre is believed to fall.

The population of *Sigmodon* was found to be 10 to 12 per acre.

The *Baiomys* population was estimated to be 6 to 8 per acre. A sudden large increase in the number of unmarked *Baiomys* occurred during the trapping period. Possible explanations for the increase are discussed.

Runways were very poorly defined. When found, they could be traced for only a few feet.

Sigmodon and *Baiomys* were common in unburned tall-grass prairie that had a mat of dead grass, but were rare in burned prairie that was nearly identical except for the absence of the dead grass mat.

It is suggested that the low populations of small mammals on the eastern portion of the Edwards Plateau can be explained in part by two factors: 1) elimination of the grass mat by grazing, or, as at Camp Bullis, by annual burning; 2) the firmness and toughness of the stony clay soil. This may account for the scarcity or absence of burrowing rodents, including most geomyids and heteromyids.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the information and assistance supplied by Dr. Walter P. Taylor of the U. S. Fish and Wildlife Service; Mr. Dennis E. Griffith and Mr. Theodore H. McGregor, both of the Office of the Engineer, Fourth Army, Fort Sam Houston, Texas; and by Mr. Albert J. Kirn, Somerset, Texas.

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LIFE HISTORY NOTES ON PRICE AND BAILEY POCKET MICE OF SOUTHERN ARIZONA

BY HUDSON G. REYNOLDS AND HORACE S. HASKELL

Certain data bearing upon the life history of the Price pocket mouse (*Perognathus penicillatus pricei* Allen) and the Bailey pocket mouse (*P. baileyi baileyi* Merriam) were accumulated while studying the abundance of small seed-eating rodents in southern Arizona. Data are limited and conclusions tentative, but it is hoped that some of the characteristics and ecological relations of these little-known rodents are suggested.

This work was conducted by the Botany and Range Ecology Department of the University of Arizona. Dr. C. T. Vorhies and Dr. R. A. Darrow of the University of Arizona contributed materially to the study. The former graciously allowed the use of museum facilities for animal identification and critically read the manuscript, and the latter generously assisted in the identification of plant materials. Dr. S. Benson and Dr. A. S. Leopold of the University of California critically read the manuscript. The Director of the Southwestern Forest and Range Experiment Station generously provided facilities, and other members of the Station gave helpful advice and assitance.

Area and methods.—All animals were captured on the Santa Rita Experimental Range which is maintained by the Southwestern Forest and Range Experiment Station near Tucson in southern Arizona. Trapping was confined to the vegetal transition zone between the semi-desert grassland of the higher foothills and the desert shrub of lower elevations. Density of the major perennial grasses, such as the three-awns (*Aristida* spp.), cotton grass (*Trichachne californica*), bristle grass (*Setaria macrostachya*), and gramas (Bouteloua spp.) was low. A heavy invasion of burroweed (*Happlopappus tenuisectus*) and mesquite (*Prosopis juliflora* var. *velutina*) characterized most of the area. During favorable rainfall years, an abundant cover of numerous species of spring and summer annual grasses and forbs was present.

All rodents were captured in museum break-back traps which were baited with rolled barley. During 1942, trapping was done at sporadic intervals, but in 1946, traps were set at regular monthly intervals from March through November. In both years, trapping was systemized by randomizing lines of ten traps spaced fifteen feet apart over the trapping area. Field records were kept of breeding condition, weights, measurements, sexes, and ages of the animals on each trap line. Cheek-pouch contents were collected and later identified in the laboratory.

TABLE 1.—*Pouch contents of pocket mice expressed as percentage of occurrence of total number of pouches containing vegetal materials*

PLANT	ANIMAL		
	pricei 1946	*baileyi* 1946	Both Species 1942
Annual Grasses			
Aristida adscencionis	6	18	6
Bouteloua aristidoides	—	9	2
Chloris virgata	6	—	—
Eriochloa gracilis	6	—	2
Panicum arizonicum	6	—	13
Panicum hirticaule	—	—	6
Perennial Grasses			
Aristida hamulosa	—	18	4
Aristida ternipes	—	5	2
Heteropogon contortus	—	4	—
Pappophorum wrighti	—	5	—
Setaria macrostachya	12	9	11
Trichachne californica	—	9	—
Grass culms	6	4	—
Annual Forbs			
Boerhaavia torreyana	6	9	6
Cassia leptadenia	—	—	2
Daucus pusillus	—	—	6
Euphorbia spp	—	14	—
Kallstroemia grandiflora	—	4	—
Lotus humistratus	—	5	11
Lupinus spp	—	—	6
Pectocarya recurvata	—	4	4
Plantago spp	—	—	4
Talinum auriantiacum	—	—	9
Trianthema portulacastrum	6	—	2
Perennial Forbs			
Aristolochia watsoni	—	—	4
Ayenia pusilla	—	—	2
Boerhaavia caribaea	—	14	4
Ditaxis neomexicana	—	4	2
Evolvulus arizonicus	12	—	13
Sida diffusa	—	32	13
Solanum elaeagnifolium	—	—	2
Forb leaves	—	—	4
Shrubs			
Acacia spp	—	4	2
Celtis pallida	6	—	11
Cercidium spp	6	—	—
Krameria glandulosa	6	—	—
Opuntia engelmanni	29	27	15
Opuntia fulgida	6	18	13
Prosopis juliflora var. *velutina*	29	4	19
Yucca elata	—	—	2
Zinnia pumila	—	—	2
Miscellaneous			
Gravel	—	—	4
Dung	6	—	2
Unidentified	6	—	9
Number of pouches	17	22	47

Food habits.—Table 1 summarizes the vegetal remains which were identified in cheek pouches of both *baileyi* and *pricei*. Plant names are based upon the taxonomy given by Kearney and Peebles (1942). Percentages given for each plant species refer to the number of times in one hundred that any plant species occurred among all of the pouches which contained vegetal material. About 80 per cent of both species of pocket mice had empty cheek pouches. During 1946, pouch contents were segregated by animal species, whereas in 1942 no separation was attempted.

Seeds made up more than 90 per cent of the pouches containing vegetal material. Less than five per cent of the pouches contained leaves or stems of plants. With regard to broad plant groups, decreasing order of preference was for shrubs, forbs, and grasses. Except for cheek pouches of *baileyi* taken in 1946, perennial grass seeds occurred least frequently of any plant group. Seeds of large size occurred more frequently in the pouch contents than did smaller seeds, irrespective of plant group. Minute seeds, such as those of certain of the perennial gramas and muhly grass (*Muhlenbergia porteri*) were not found in the pouches, although seed was produced by such plants on the trapping area. Possibly seeds of these plants are so small as to limit discovery and to discourage handling by pocket mice. The high percentage of cactus seeds in the pouches can probably be attributed to the large size of these seeds and to the intermittent falling of the fruits over an extended period, resulting in a long season of availability.

The most commonly occurring seeds in pouches of *baileyi* were cacti (*Opuntia* spp.), false flax (*Evolvulus arizonicus*), spurge (*Euphorbia* spp.), and annual and perennial three-awns. The seeds of mesquite, cacti, false flax, and bristle grass (*Setaria macrostachya*) were found most commonly in the pouches of *pricei*. The fact that the pouches of *baileyi* contained relatively larger amounts of perennial grass seed, and *pricei* greater amounts of mesquite and cacti, may be a reflection of habitat. Bailey pocket mice were slightly more abundant near the upper portions of the Experimental Range where perennial grass was more dense; Price pocket mice were more common where the perennial grass cover was thinner, and the invasion by mesquite and cactus was more pronounced. The availability of seed from year to year also produced differences in food items taken by both species.

Body measurements.—Average measurements of both species of pocket mice by sex are given in Table 2. Only mature animals were included in the measurements. Average, standard error, and range are given for each characteristic. Body measurements were made according to the accepted museum technique; weights were taken on a spring balance.

Bailey pocket mice, on the average, are larger and heavier than Price pocket mice, although individual measurements of tail length and hind foot overlapped between the species. Males averaged significantly heavier and larger than the females with respect to body length and weight for *baileyi*. The sexes of *pricei* did not differ in size or weight within the significance of the sample sizes. Pregnant females were expectedly heavier than those animals containing no embryos —*pricei* and *baileyi*, pregnant females, weighing 18 $\pm$ 1, and 23 $\pm$ 2 grams, respectively.

Breeding habits.—Breeding activity of both species was confined to the spring and summer months. The first pregnant females of *baileyi* were taken in April; of *pricei* in May. The latest months in which pregnancy was recorded for the two species were August and September, respectively. Percentages of males with scrotal testes and females containing embryos are given in Table 2. Breeding activity was highest during the late spring months for both species of mice. During the drought period of June and early July, breeding response dropped off, but it gained impetus again during the month of August. These periods of greatest sexual activity were concurrent with seasons of new vegetative growth of the spring and summer.

TABLE 2.—*Body measurement statistics and breeding activity of Bailey and Price pocket mice*

CHARACTERISTIC	BODY MEASUREMENTS			
	pricei		*baileyi*	
	Male	Female	Male	Female
Total length (mm)	172 ± 2.0 (155–185)	170 ± 1.0 (162–178)	214 ± 2.0 (189–235)	203 ± 2.0 (197–226)
Tail length (mm)	93 ± 1.0 (83–104)	94 ± 1.0 (85–110)	118 ± 1.0 (107–132)	113 ± 1.0 (100–127)
Hind foot (mm)	23 ± 0.2 (21–24)	23 ± 0.2 (21–25)	27 ± 0.3 (25–30)	27 ± 0.6 (24–29)
Weight (gms)	16 ± 0.4 (13–20)	16 ± 0.6 (13–20)	33 ± 0.8 (27–42)	28 ± 0.9 (25–35)
Breeding Animals, Per Cent				
Season				
Winter	0	0	0	0
Spring	90	45	80	25
Summer	50	25	40	20
Fall	0	0	0	0
Number of animals	26	24	28	18

Pregnant females of *pricei* averaged 1.7 embryos in each horn of the uterus for a total of 3.4 (2 to 4) young per female. Arnold (1942) reports an average of 4.4 fetuses per female for this species. Too few pregnant *baileyi* were captured for a significant average, but each side of the uterus most commonly contained two embryos (four young per female).

Populations.—Per acre estimates of pocket mice numbers were compiled according to the method advocated by Dice (1938). Effective area trapped was considered to be that which was included within a border equal to one-half the average cruising radius of the species around each trapping line. Limited live-trapping suggested that the territory of the pocket mice was about one-half acre (.3–.6 acres).

Figure 1 gives the numbers of pocket mice by sex and age for the trapping period of 1946. Both populations of mice averaged about three acres per ani-

mal for the trapping period. Greatest numbers of animals were captured during the summer months when immature animals were most abundant.

The variations in numbers of pocket mice with the season of the year are possibly referable to hibernating tendencies. Though not definitely established that hibernation occurs, the scarcity of animals in traps during the winters suggests that such is the case. No Price pocket mice were captured during the period December to February. Arnold (*op. cit.*) failed to catch any *pricei* during the winter on areas that yielded heavy populations during the summer months.

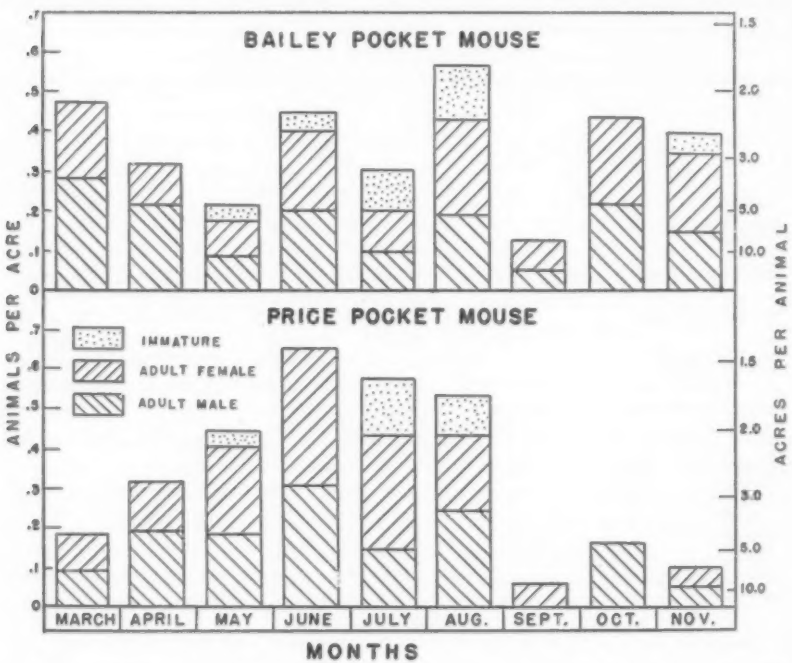

FIG. 1.—Populations of Price and Bailey pocket mice, by sex and age, for the trapping period of 1946.

Scheffer (1938) reports a period of dormancy during the winter in the pocket mice of Oregon and Washington, but states that periods of wakening occur intermittently during this time. The inferred tendency to hibernate does not appear to be as strongly developed in the Bailey pocket mice. The numbers of this species were fairly consistent during the winter trapping period of 1946, and occasional individuals were taken throughout the winter of 1942. Variation in numbers of *baileyi* from month to month is probably referable to errors in sampling.

Sex ratios of both species, within the limits of the sampling technique, were approximately equal. Males did appear, however, to be relatively more abundant than females during early spring and fall months.

Habitat relations.—During the summer of 1946, paired trapping quadrats were located inside and outside of several exclosures which had been protected from livestock grazing for a number of years. Perennial grass density (abundance of plants) was consistently greater inside the exclosures where protected than outside where the grass was being grazed (Table 3). Both species of mice were consistently more abundant on the protected areas. Apparently, perennial grass cover favors populations of pocket mice. These small animals depend largely upon protective coloration and "freezing" to avoid detection. Accordingly, a fairly dense stand of perennial bunchgrass would serve more effectively as protection from predators than would an open, highly dispersed stand of grass.

TABLE 3.—*Comparative numbers of pocket mice on areas grazed and ungrazed by domestic livestock*

TRAPPING AREA	GRAZING TREATMENT	PERENNIAL GRASS DENSITY	NUMBER PER ACRE	
			baileyi	*pricei*
		per cent		
I	Ungrazed	1.6	4.3	1.4
	Grazed	0.5	1.9	1.4
II	Ungrazed	0.4	1.9	1.4
	Grazed	0.4	1.4	0.5
III	Ungrazed	0.6	1.0	1.0
	Grazed	0.05	0	0.5
IV	Ungrazed	1.5	1.0	0
	Grazed	0.5	0.5	0
V	Ungrazed	1.1	1.0	0
	Grazed	0.7	0	0
VI	Ungrazed	0.4	0	0.5
	Grazed	0.2	0.5	0
Average	Ungrazed	0.93	1.53	0.72
	Grazed	0.40	0.72	0.40

Moreover, when grazing animals clip the plants back to a short stubble height, the protective overstory for the rodents is destroyed. A low stubble height and relative low grass density thus tend to produce an unfavorable environment for these small rodents.

Economic status.—Economic evaluation on the basis of such a small amount of data can be only suggestive. Within the limited scope of the study, pocket mice appear to be a negligible influence with regard to the primary utilization of the land—that of grazing domestic animals. On the area of study, with such relatively small numbers of these rodents, and with their food selection for the most part confined to seeds of plants of little or no value to grazing livestock, these rodents can scarcely be considered important vegetal influences.

Although pocket mice apparently attain greater populations as the perennial grass density increases, animal numbers even in the best stands of grass of this area of study were so low as to be of insignificant importance with regard to plant reproduction through destruction of seed. If the density of a perennial grass

stand is reduced because of unsatisfactory management practices or unfavorable climate, pocket mice numbers presumably decrease. Moreover, grazing in itself, by reducing the stubble height of bunchgrasses, produces a less favorable habitat, and lowers pocket mouse numbers. The conclusion is offered that little or no attention need be given pocket mice under ordinary conditions of managing range lands for the grazing of domestic livestock in this region.

Summary.—Limited data are presented on food habits, body measurements, breeding habits, and populations of Price and Bailey pocket mice in southern Arizona.

Food items found in the cheek pouches consisted chiefly of large seeds of unimportant range plants. Seeds of desirable perennial grasses were not eaten in any quantity.

Populations of pocket mice were found to be generally low, averaging about three acres per animal. The highest population occurred in ungrazed stands of perennial bunchgrass where abundance of plants was relatively greater.

Because of the low numbers and inoffensive food habits, little or no concern need be given to pocket mice in the management of these particular ranges for domestic livestock grazing.

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LIFE HISTORY NOTES ON THREE MICE FROM THE FLORIDA EAST COAST

By R. DeWitt Ivey

The occurrence of three species of *Peromyscus* on a barrier island of the Florida east coast, lying between St. Augustine Inlet and the mouth of the St. Johns River, provided an opportunity for the comparative life history studies reported here. The animals investigated are the Anastasia Island beach mouse, *P. polionotus phasma* (Bangs), the cotton mouse, *P. g. gossypinus* (LeConte), and the golden mouse, *P. nuttalli aureolus* (Audubon and Bachman). Data were collected over two different periods; (1) from the fall of 1939 to the spring of 1942, during the course of general explorations in the area, and (2) from the fall of 1946 to the spring of 1947, in connection with a mammal survey.

The barrier island on which the present study was made is separated from the mainland by a series of tidal marshes and hardwood swamps, connected at present by a canal of the Intracoastal Waterway system. The island includes a narrow strip of beach and dunes facing the ocean and a broader belt of variegated terrain sloping gradually inland. The dune belt is from 25 to 500 feet in width, and consists of one or more ranges of white sand dunes reaching a maximum altitude of about forty feet above sea level. The westernmost ridge is generally the highest and serves as a windbreak for the landward side of the island. The dunes themselves are directly exposed to prevailing winds from the east. The dune strip supports several types of low vegetation, the most usual dominant being sea oat, *Uniola paniculata*, or saw palmetto, *Serenoa repens*. The leeward side of the island varies from a few hundred feet to a mile or more in width and supports more luxuriant vegetation. Plant communities found here include hammock, hardwood swamp, cypress swamp, scrub, pine flatwoods, fresh-water marsh, and salt marsh. All of these communities are inhabited or visited by at least one of the three species of *Peromyscus*.

The methods used in this study were varied as a result of the contrasting habits of the animals investigated. Systematic trapping with Sherman live-traps was found successful for beach mice and cotton mice. In addition, beach mice were captured and studied by excavation of burrows, and cotton mice were taken by hand from their various types of nests. Golden mice were not taken in traps, but were captured manually from their suspended nests. Sight records and other notes were obtained in the course of night observations with a headlight. Additional observations were made on captive specimens of all three species.

My companion and co-worker in much of this study, particularly the hand collecting, was Charles C. Burner of Jacksonville, Florida. I am also indebted to Professor H. B. Sherman, of the University of Florida, without whose interest and help certain phases of this study would not have been possible.

ACCOUNTS OF SPECIES

Peromyscus polionotus phasma (Bangs). Beach mouse.—This animal can be differentiated readily from the other two forms studied by its somewhat smaller size, and by the pelage. The adult mouse is pale buff with a white spot generally present over the eye and at the base of the ear; young individuals are pale, neutral gray.

The present study extends northward the known range of this subspecies, which, according to Bangs (Proc. Boston Soc. Nat. Hist., 28: 157–235, 1898), is confined to Anastasia Island and does not occur on the beaches north of St. Augustine. Bangs' conclusions are apparently based on the work of his collector, W. W. Brown, Jr., who failed to take beach mice at Burnside Beach, near the northern end of the island concerned in the present study. He undoubtedly assumed that a water barrier would be the limiting factor in the northern distribution of this subspecies. While the writer's observations substantiate Bangs' report that beach mice are not found in the northern part of this island, they show that the animals are abundant in the uninhabited dunes of its southern half. Specimens were taken from St. Augustine Inlet to the border of St. Johns and Duval Counties. The northernmost specimen was collected well inside the series of resort communities occupying much of the island's northeastern shoreline.

Distribution and habitat preferences of beach mice were determined by systematic trapping and by observations made on tracks and burrows. Burrows are not reliable as evidence of the presence of beach mice except when excavated, since they may be readily confused with the burrows of sand crabs. The confusion is intensified by the presence of chewed seeds and beach mouse tracks at the entrances of beach mouse and sand crab burrows alike.

Beach mice were recorded from most of the more open dune habitats, especially the bare sands and the sea oat communities. They were not found in damp, grassy hollows, or in dense saw palmetto growths, and were not taken from the upper beach or from the back dune slope where this was covered by hammock trees. Four hundred and fifty trap-nights just inside the back dune hammock failed to catch a single individual, indicating that the area inhabited by the beach mouse does not extend outside the narrow strip of open dunes.

Concerning the food of this animal, Bangs (*loc. cit.*) mentioned that a related subspecies, *P. p. niveiventris*, is dependent on the sea oat, *Uniola paniculata*, and that it is found only where this plant is abundant. The abundance of sea oat panicles does not necessarily indicate an abundance of food, however, since these plants bear a surprisingly small number of well-filled seeds. Stomachs from *P. p. phasma* taken in snap traps contained a whitish mass, probably derived from seeds. In addition to sea oats, whole or fragmented seeds of *Strophostyles* sp. and *Panicum* sp. were found in the entrances and in the vicinity of beach mouse burrows.

The burrows of this animal are situated in a variety of places. Some are located on relatively level ground, as in the bottoms of bare, wind-swept hollows, or on high, grassy plateaus of the back dunes. Some occur on almost perpendicular banks, up which the mice apparently must climb by means of exposed palm or sea oat roots. Among the smaller, more active dunes the entrance to the burrow may be located on a moderate slope some distance below a growth of sea oats, while the escape tunnel leads up into this vegetation.

In structure the burrow of *P. p. phasma* is similar to that of other subspecies of *P. polionotus*, as described by Hayne (Jour. Mamm., 17: 420–21, 1936) and Rand and Host (Bull. Amer. Mus. Nat. Hist., 80: 1–21, 1942), except that it is more often constructed in steep dunes and frequently varies to conform to the topography. There is generally no extracted pile of sand, as this slides down the dune or blows away. From the entrance, a main tunnel, which is 1.5 to 2.5 inches in diameter, descends at a moderate slope for about 2.5 feet, leveling slightly before it enters the larger nest chamber. The latter is a spherical or ovoid cavity, five to ten inches in diameter. The nest, composed of sea oat roots, stems, leaves, and the chaffy parts of the panicles, occupies about one-fourth of this cavity. The narrow escape tunnel extends more or less vertically from the rear of the nest chamber, rising to within a few inches of the surface. In addition, there are generally one or two short tunnels leaving the cavity. These tunnels end blindly and are used as dung deposits and possibly as storage burrows.

The escape tunnel is apparently a place of concealment as well as an exit, for while a burrow is being excavated, the mice usually run up the narrow passage and wait for a time before bursting through to the surface. This final dash for safety is sometimes postponed until the digger has excavated far up the escape tunnel.

The manner of digging by individuals of this subspecies is similar to that described by Rand and Host (*loc. cit.*) for the species. The mouse assumes a straddling position and throws sand back between the hind legs with the forefeet. The hind feet are then used vigorously to kick the sand back a distance of a foot or more, while the animal backs slowly up and out of the burrow.

Data concerning breeding and family behavior were obtained in only two instances. One of these records is of a family of eight, composed of both parents and six young, taken from a burrow on April 14, 1942. The other is of a female, taken October 27, 1946, with five embryos which were estimated to be about 15 mm. long (crown-rump measurement).

Beach mice proved to be the most sociable group of *Peromyscus* studied. Groupings of various subspecies within a single cage were tried, and in all cases the animals accepted each other readily. Cannibalism was observed in some instances after the animals involved had been living together amicably for some time. Compatibility is the rule, however, and periods of fighting and squabbling are rare.

Captive beach mice are more vivacious than golden mice or cotton mice, and at times appear almost shrew-like in their constant activity. They tame readily and their activities are always more open and demonstrative than are those of the other species. They respond as readily to frightening stimuli as do the others, but are quicker to recover. Their activities do not appear to be guided by as definite purposes as do those of cotton mice, but rather to be the result of innate exuberance. The exercise wheels are especially used by them, and often at a slight noise they leap onto the wheels and run them vigorously as though escaping from danger. When fresh sand is put into the cages, beach mice become unusually frisky, and soon have every part of the sand beaten down with tracks. This calls to mind the great numbers of tracks which are frequently found in dunes where few burrows occur. As each day brings a clean, new surface to the dunes, it seems likely that a similar reaction may occur in the wild state.

Peromyscus gossypinus gossypinus (LeConte). Cotton mouse.—This mouse is the largest and darkest of the three species studied. Adults may be distinguished from the other two forms by their relatively large size and by the dark cinnamon or rufous color. The young are a very dark, neutral gray.

The cotton mouse is one of the most abundant mammals in this area. It is characteristic of several plant communities, but tends to prefer wooded and damp situations. It is most numerous in hydric hammocks and in hardwood swamps that are not wholly flooded, but specimens are frequently taken in drier hammocks. This species is also characteristic of the flatwoods, where it is commonly found about the edges of small ponds and fresh-water marshes. In the present study specimens were also taken in dunes.

Although no organized population study was undertaken, general observations indicated that cotton mice were much more numerous in the 1939–42 period than in 1946–47. This difference in relative abundance of the species was first suggested by the fact that occupied nests were numerous in the earlier period and were found in a great variety of places, while in the later period no occupied nest was found and old nests were very scarce. In 1946–47 the writer took only eight specimens in 2300 trap-nights in cotton mouse habitats.

Nests were most frequently found in hollow palm logs. The outside of this type of log forms a hard, durable shell, while the pithy interior is usually in a more advanced state of decomposition. This material does not have the appearance usually associated with rotting, for while it becomes so weak as to fall apart in the hands, it retains its clean white and buffy colors and a fresh, agreeable smell. The pith forms a fluffy or flaky meal, and the fibrous material freed from the pith makes a fine tow. Cotton mice make nests of this fiber with the occasional addition of a lining of saw palmetto fiber or other material. The nests are generally placed where decomposition has produced a considerable hollow in the log, while numerous tunnels extend into the firmer parts. The nests observed were roughly spherical and were much thinner on top than on the bottom. They were set in saucer-shaped depressions in the mealy material.

In 1940 it was common to find several nests in one log, although no record was obtained for more than one family nesting in the same log. At times, however, it appeared that a group

of half-grown young were occupying one nest in a log, while the mother with a second litter of young occupied another nest in the same log. Two adults were not found using the same nest.

Cotton mice were also found nesting in other situations, particularly during the 1939–42 period, when the variety and number of nesting sites suggested overcrowding. Several nests were constructed on the ground under dead palmetto fans. One uninhabited nest, probably of the cotton mouse, was placed in a rather open position among the roots and bases of a clump of palmettos. Occupied nests were also found in oak logs and in a standing pine stump.

Data concerning breeding were obtained only during winter months. A female with seven newborn young and a litter of older young was taken on January 9, 1940. A female containing four 11-mm. embryos was taken on December 31, 1946, and another with six 24-mm. embryos was taken on February 9, 1947. Specimens in juvenile pelage also were taken during December and January. Three males with testes averaging 17.3 mm. in length were taken on November 25 and December 21 and 23, 1946.

At night, cotton mice may easily be seen running about the trunks and limbs of hammock trees with great freedom and agility. The mice are very curious. When frightened away by the night observer, they show themselves again after a short period of silent waiting. On one occasion an adult cotton mouse approached our campfire and remained only a few feet away for some time.

It was frequently the experience of Mr. Burner and myself, while walking quietly along the hammock trails at night, to hear some distance ahead in the trees what seemed to be a number of mice uttering prolonged squeals and squeaks, in unison and individually. This was thought to be a cotton mouse singing session, as animals of this species were the only ones that had been observed in the trees by the use of a headlight. On some occasions we remained quiet until the sound began again, but it invariably ceased as soon as a light was flashed on. These notes somewhat resembled sounds made by captive cotton mice. Singing, in *Mus*, *Peromyscus*, and *Reithrodontomys*, has been discussed by Dice (Jour. Mamm., 13: 187–96, 1932).

Captive cotton mice occasionally are heard to utter short, musical, barking sounds, not the same as the squeal uttered when fighting. They grate or chatter the teeth noisily, or drum with the feet when angry or disturbed. The drumming was observed to be done by only one foot at a time, although either a fore foot or hind foot was used. Sometimes in one continuous drumming all of the feet are used in random sequence.

Captive *gossypinus*, while not accepting confinement as readily as did beach mice, engaged in considerable activity. This included running exercise wheels, playing together, and finding ingenious methods of escape. Wild-caught adults never became tame, but young of wild-caught parents tamed readily. On several occasions, when cotton mice escaped from their cages, they conducted themselves with much more of the spirit and craft of house mice than did other species of *Peromyscus* studied.

Peromyscus nuttalli aureolus (Audubon and Bachman). Golden Mouse.—This species can easily be distinguished from the preceding two by its bright rusty-orange color. The young are only slightly less brilliant than the parents.

The presence of golden mice can be determined by locating the highly characteristic arboreal nests. In 1939–42 over 1000 nests were examined and about forty mice were taken by hand. They were frequently found in hammock edges, where the taller vegetation descends gradually to meet the surrounding scrub. Nests were equally characteristic of the deepest parts of the hammocks, where a dense growth of magnolia shades out almost all undergrowth. They were also found by the writer in a hardwood swamp and in a cabbage palm hammock. Farther inland, in Duval County, they were discovered in isolated oak thickets in the flatwoods and in a turkey oak community.

In general, golden mice appear to live in rather loosely knit communities consisting of three or four occupied nests. Where one nest is discovered there are likely to be others, while in large tracts of similar country it is often impossible to find a single nest. Occupied

nests were greatly outnumbered by unoccupied nests. Two possible explanations for this condition are: (1) nests were found to remain intact for over a year after being deserted, and (2) observations indicate that the mice often desert nests after being frightened away only once.

In placement of the nest, golden mice appear to have a definite preference for certain altitudes. Nests are located most commonly at four to six feet above the ground. The average height of eleven nests measured in a Palm Valley hammock was five feet. An unusually high nest not included in this average was fifteen feet. Occasional nests are also found within a few inches of the ground. Strangely, many nests are placed within easy reach of carnivores.

Various types of structures are used to support the nests. A rather weak situation, such as a strand of Spanish moss or a cluster of small vines or branches, is generally chosen. One nest was found hanging, like an article on a clothesline, almost midway between two cabbage palms on a slender, leafless vine. Another had been built against a cabbage palm trunk, resting on the base of a dead frond. Several were constructed upon one and under another saw palmetto fan. The majority of nests, however, are in hanging Spanish moss or in tangles of smilax vines.

Golden mouse nests are roughly globular structures, from three to six inches in diameter. There is one conspicuous opening, which is about an inch in diameter and is often partly closed, in occupied nests. At the side opposite the entrance, there is generally a thin place in the wall through which the animal can burst in making an escape. When the nest is placed in Spanish moss, the living plant is generally woven into and around it, anchoring it securely. In other situations the strong, black fibers of dead Spanish moss are frequently used to anchor the nests.

The materials of the nest are laid down in distinct layers, three being the most usual number. The outer is generally of compactly woven Spanish moss fiber; the middle and thickest layer is usually of saw palmetto fiber or the inner bark of red cedar; the inner lining is of the softest material available, such as finely shredded cedar bark or Spanish moss down.

Many individual variations occur. The inner layer is at different times composed of various soft materials, including some of highly local or seasonal occurrence such as shredded paper, cotton, feathers, and fruit or flower parts. The outer layer is the most variable of all. In some nests it contains an enormous number of twigs, from one to three inches in length, woven into the moss fiber. In others, the moss fiber contains many imbedded deciduous leaves. In some a bulky layer of deciduous leaves entirely replaces the moss fiber. Nests are frequently found in which the usual outer layer is completely lacking.

Where several nests are found close together, they tend to be alike in construction, and are probably built by the same individual. Mice which appear to be young, as judged by color and size, are sometimes found in very simple nests, composed almost entirely of a single type of fiber.

Golden mice apparently range the surrounding countryside in search of proper nesting material. Nests employing much palmetto fiber are sometimes located many yards from the nearest palmetto. A tremendous amount of Spanish moss must be canvassed to collect enough down for the lining of a single nest. The mice are also quick in taking advantage of chance opportunities. For example, cotton trap-markers placed in bushes and trees on one day were often found incorporated into nearby golden mouse nests on the following day.

Golden mice kept in captivity always exhibited great discrimination in the choice of nesting materials and sites. When free in a room, they repeatedly showed a preference for woolen goods, which they skillfully shredded into an extremely soft fluff. A similar degree of skill was exercised on other coarse materials, the inevitable result being a finely divided tow. Although not closely observed, this preparation was seen to employ the use of both hands and teeth. Selected materials were always transported to an elevated place, such as the top of a cabinet or the pocket of a coat, where they were incorporated into a nest. One captive mother was observed carrying her young from the open cage to the top shelf of a bookcase, a height of about three feet.

On one occasion materials were placed inside a cage and the mouse's usual nest removed. These materials included saw palmetto fiber, dried grass, pine needles, oak leaves, and cotton. A piece of Spanish moss was hung inside the cage. By the following morning a nearly typical golden mouse nest was present. It was suspended in the Spanish moss and was composed of an outer layer of moss fiber, a middle layer of palmetto fiber, and a lining of cotton, the other materials having been rejected.

Nests frequently contained more than one inhabitant. Males generally occupied nests by themselves, although pairs were sometimes found together. Males were not found in nests containing young. Groups of more than two were almost always composed of females with young, although the young were sometimes nearly as large as the parent. Young of two ages were not found in the same nest, but on one occasion a pregnant female was suckling young.

Breeding data for this species also were collected only during winter months. A female containing four 5-mm. embryos and a single nursing young was taken on November 3, 1946. On December 21 of the same year a female was taken with young about one and one-half months old. On December 21, 1941, a female was taken with three young about one week old.

When frightened from a nest, golden mice nearly always climb the nearest bush or tree. Frequently, when shaken to the ground, they creep a few yards before starting to climb. After ascending to a height of a few feet they generally freeze in full view.

In climbing, golden mice ordinarily use the tail as a prehensile organ, keeping the flexible, distal end coiled around vines or twigs as much as possible. This type of tail is undoubtedly an asset in the construction and use of golden mouse nests, which are often precariously situated.

Golden mice differ remarkably in temperament from beach mice and cotton mice. Captives appear stupid, almost reptilian in their actions. This seems to be a result of extreme nervousness and somewhat resembles the condition of a cottontail rabbit in captivity. In captivity as in the wild state, golden mice characteristically respond to frightening stimuli by climbing upward. At such times they are extremely slow in recovering and frequently remain at the top of the cage for half a day. Golden mice appear to engage in no unnecessary activities. A pair of young born in captivity were the only individuals observed using the exercise wheel.

CONCLUSION

Of the three species of mice studied, *P. p. phasma* is the most terrestrial form, being restricted to the dunes. The subspecies is not confined to Anastasia Island, but is found in dunes north of St. Augustine Inlet as well. It nests in a characteristic type of burrow, which is fairly consistent with that of other members of the species.

The cotton mouse is both terrestrial and arboreal, and is characteristic of many environments. It is not highly specialized, being versatile in its choice of nesting sites and habitats. Nests were found to be especially abundant in fallen palm trunks.

The golden mouse is an arboreal form inhabiting the hardwood forests. Its nest is a complex and skillfully made structure, arranged according to a typical plan, but showing many individual variations. Golden mice are not evenly distributed throughout the habitat, but tend to occur in isolated communities.

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THE IDENTIFICATION AND VALUE OF MAMMAL BONES FROM ARCHEOLOGIC EXCAVATIONS

By Raymond M. Gilmore

Several years ago, in the Smithsonian Institution, I completed the examination of fragments of mammalian bones from ten archeologic collections. They were from Pennsylvania, New York, Illinois, Kansas, Texas, New Mexico, Colorado, and Coahuila, Mexico. One collection contained 13,293 fragments, another 2,754, and a third, 2,109. Some had been made by members or affiliates of the Smithsonian Institution; others were from other public or private collectors. There were more than 20,000 fragments in all.

About six months were spent in the identification of the distinguishable fragments and in the preparation of the reports for the archeologists. In a few of the collections, all of the bone fragments could be identified, but in most from 25 to 75 per cent were so finely comminuted as to be unidentifiable. However, all the fragments had to be scrutinized carefully before identification or rejection.

The skeletons for comparative study came from the Smithsonian Institution and the U. S. Fish and Wildlife Service; housed in the same building (the U. S. National Museum), they proved adequate for the study.

This type of work is considered by most identifiers to be an unmitigated drudge. There is also a desire on the part of the archeologist to receive his identifications as soon as possible for his reports, with the result that the identifier's own work is interrupted. Furthermore, the novelty of making such identifications soon disappears. However, such a task of identifications may be eased greatly by (a) considering the collection to be a desirable faunal assemblage from an earlier time than the present, (b) anticipating the discovery of some important and interesting facts, (c) adopting a procedure to facilitate the work, and (d) planning to publish important zoological data.

If consulted beforehand by the archeologist, the identifier can arrange for (1) a label of each differently numbered lot of bones on a 4 in. x 6 in. card, (2) a report on the general ecology of the site-region, (3) cleaned specimens, and (4) as careful segregation of bone-lots as of artifacts (Gilmore, 1946*a*). Careful stratigraphic labeling (understandable to the zoologist) may disclose a change in fauna from the top to the bottom of the mound caused by the disappearance or appearance of species through natural or human means. There are other interesting discoveries to be made through such bone-examinations, as for instance, the occurrence of an animal outside its present range, the discovery of an hitherto unknown form, or the revelation of certain unrecognized osteologic differences between species or genera. These discoveries may have significant zoogeographic, zoologic, ecologic, climatic, or ethnozoologic implications, especially as related to historic time-sequences.

Wintemberg (1919) clearly pointed out the archeologic aids to zoology. He mentioned the discovery through archeology of the recently extinct rodent (*Isolobodon portoricensis*) in Porto Rico, the extinct marine mink (*Mustela macrodon*)

in shell-mounds of New England, and extinct peccaries in the Eastern United States; also the prehistoric extensions of range of the caribou, great auk, bison, and wild turkey, as well as the fluctuations in range of white-tailed deer in Nova Scotia, the finding of supposedly introduced European snails (*Helix*, = *Cepaea, hortensis* and *Zua*, = *Cochlicopa, lubrica*) in pre-Columbian sites of northeastern North America, the possibility of finding the similarly "introduced" shell (*Litorina litorea*) in shell-heaps, and the uniformly large size of oyster shells in prehistoric mounds. Subsequently, many other mammals now extinct, as well as extinct birds and bats, have been found in Antillean shell-mounds and human refuse in cave-sites.

Certain problems of North American mammalogy depend upon archeology for solution. Some of these problems are: The apparent absence of the native red fox along the eastern coastal United States before its known introduction from England (Rhoads, 1903; Seton, 1937; Gilmore, 1946*b*), the oscillations of range (or steady spread) of the common opossum in the northeastern United States, the phenomenon of recent local extinction (loss of range) of the elk and porcupine, and probably also the bog lemming and some other mammals, in our "southwest" (Gilmore, 1947), the recent loss of range of the rice rat (*Oryzomys palustris*) in eastern United States (Gilmore, 1946*b*), the oscillations (or steady loss or gain) of range of such Neotropical fringe mammals in the southwestern United States as the ocelot and jaguar (recent loss) and the coatimundi, raccoon, and jaguarundi cat (recent gain), and in the southern United States of the nine-banded armadillo (recent gain), the probable prehistoric extension of range of the red wolf far up the Mississippi valley, the recent prehistoric survival of the extinct ground sloth in the southwestern United States, and the former extension of range of the grizzly bear on the great plains. An appreciation of these problems gives a realization of the value and interest to be derived from a study of the archeologic remains of mammals. I have looked in vain among recent books on North American mammals for even a mention of most of these problems, so apparently they are not well known. However, Seton was well aware of many of these problems of range-shift, and in his classic and comprehensive "Lives of Game Animals" (1909, 1925, 1937) he mentioned them. Rhoads (1903: 146–147) gave considerable space to the problem of the red fox in eastern United States.

Zoological findings can be of aid to archeologists and anthropologists in interpreting their finds culturally, and Baker (1930) attempted this aspect of the work. However, these interpretations generally should be made by the anthropologists.

Local state and university museums can undertake profitably this type of work, because they generally have the most up-to-date knowledge of the local fauna, and also have or can make a complete skeletal collection of local species for direct comparison, in numbers perhaps sufficient to allow of statistical treatment. Accuracy is the most important desideratum, especially when the collection contains domesticated animals, or any critical species which by its known historic extension of range is a faunal time-marker, or when there are any other species of importance.

A PROCEDURE

1. A list of mammals should be prepared to include those which are expected to occur in the site-region. This list will focus attention on the most common species in the area today and on the species most likely to be encountered in the refuse of the archeologic site, as well as on the species to which reference should be made in case a bone at first cannot be allocated to one of the common forms.

2. A collection of complete skeletons of the expected species should be assembled for comparison around the work table or in an adjacent case. One or two adults, and one immature if available, should be included in this reference collection. Availability must have been the dominant factor in selection of animal food by the aborigines, and consequently, remains of many young of the common species as well as remains of some old individuals or rare or unexpected species are to be anticipated. Young animals are most numerous in the spring and summer seasons, and are more palatable than adults. Furthermore usual and unusual pet animals have left their bones, sometimes interred with special care.

Each bone of each comparative skeleton must have a museum number, because when making direct comparison between several species simultaneously, bones are separated from their skeletons and are unavoidably mixed.

Several skeletons of birds (preferably of the common food species, such as turkey, grouse, and ducks), as well as several skeletons of turtles, frogs, and fish, should be available for comparison. This enables one to allocate quickly the non-mammal bones to other vertebrate classes with fair certainty during the original examination.

3. Identifications should be entered on 4 in. x 6 in. cards. The archeologist should supply one for each differently labeled lot, and it should correspond with that on a package of bones which represents a "lot." The "level" of excavation should be included on each card. The lower the level, generally speaking, the older the specimens.

4. Only one bag of bones should be examined at a time. The individual archeologic bone fragments are ordinarily not numbered, and consequently each separately numbered lot must be completed and replaced in its original container before another is opened for study.

5. Bone fragments should be identified down to the species if possible; subspecific identifications generally are unnecessary, and in fact, are usually impossible with skeletal material only. There may be difficulty in identifying even the species of certain genera at first, but sooner or later a critical bone fragment may be found, and then at least one species of the genus can be identified positively as occurring in the collection. For example, deer bones are common in aboriginal refuse heaps in regions where either or both the white-tailed and mule deer occur; but until a critical skeletal part, such as the area with the facial pits, a complete antler, or a complete mandibular symphysis (with teeth) is found, the species may not be determinable.

6. When identifications are entered on the card, include a list of the fragments, e.g. "White-tailed deer (*Odocoileus virginianus*)," and beneath, in a column, "frag. rib . . . . 3; frag. mandible . . . . 2; astragulus . . . . 1," etc. Some identifications will be questioned later, even by the identifier himself, and it is well to be able to refer quickly, as a preliminary check, to a list of the actual fragments in order to determine how diagnostic they were in arriving at a positive identification. This is especially important in the identifications of domesticated animals, as most are obviously post-Columbian. An identification of a sheep, pig, cow, or horse based on a rib fragment from an obviously ancient site would make any archeologist unhappy, if not a bit skeptical. Teeth of adult bison are indistinguishable from those of adult cattle, and a tooth identified as the latter from an otherwise pre-Columbian site probably should be considered as bison. (G. M. Allen, 1920, stated that the milk teeth of the two species could be distinguished.) In addition, a note should be made of the age of the animal as indicated by the size of the fragments and closure of the epiphyses. An archeologist would interpret a great number of young animals from the same level as indicating the spring and summer season (if the depositional processes were rapid). There will be cases where associated bones of the same species from the same lot will belong apparently to the same individual, and such a conclusion can be noted on the card. This will eliminate chances of mistaken interpretation as to relative abundance of a species based on a large number of bone fragments belonging to one or to several individuals. Otherwise, in general, a large number of bone fragments of a species indicates relative abundance at the site-area during deposition, because dissociation and absence of most bones of one individual are much more common than association and completeness. The above reasons clearly indicate, I believe, the desirability of noting the nature and number of the identified fragments on the card of each lot.

7. All questionable bone fragments, as well as bones belonging to species of extreme interest, should be separated at the time they are encountered. They should be placed in a separately numbered container, or the bones themselves may be numbered with the number of the lot. It will be necessary invariably to refer to these questionable and "special" bones again, and some will be desired for permanent preservation. Such bones will comprise those of certain domesticated animals, or those of species no longer found in the region, or those suspected of being slightly different from their living descendants in the region today. This is an important point, because doubts as to one's own identifications of questionable and critical species always arise, and the pertinent bones will be desired in all good conscience for re-examination. They should be readily available. These specimens, which may be kept permanently in the collection for future reference, can be noted as "saved" on the card.

All bird, reptile, and fish bones, and molluscs, may be placed in individually numbered containers, each class separated, for subsequent identification by yourself or someone else. All bones of each class can be easily assembled so that they can be studied at the same time.

8. It is not advisable to work more than four hours daily on the identification

of large collections. Longer daily work over many weeks will induce mental fatigue at a surprisingly rapid rate. During the course of the work, reference can be made to the literature, to the solution of taxonomic questions on the basis of recently collected museum material, or to any other work which will apply to the interpretation of the collection and which will assist in summarizing the data.

9. Notes on any ideas or facts gained during the course of the identifications should be written at once. These can be elaborated or rejected later when preparing the final report. It is remarkable how fast these ideas and facts, hitherto unknown to the identifier and appearing suddenly, later disappear from the memory.

10. In preparing the report on the collection, mention can be made not only of the species present in the collection and the possible significance of their presence and abundance, but also of the expected species *not* found in the collection and the possible significance of their absence. The unexpected absence of a species may be important; it may mean actual absence from the region at the time of aboriginal occupancy, or it may mean purposeful or accidental nonutilization by man. In the former case, an historic fixation of the date when the animal arrived or was introduced to become a member of the present fauna will render the species a faunal time-marker in archeology. Its presence in the site certainly indicates a post-introduction date; its absence *might* mean a pre-introduction date. Such may be the case with the red fox in the eastern United States where the animal is supposed to have been absent from the native fauna and to have been introduced between 1650 and 1750 for fox-hunting purposes from England.

When several different though neighboring archeologic sites are represented in the collection of bones, the number of bones of each species can be tabulated by sites. Often there is a differential abundance of species according to the site, which in turn depends on the different ecologies involved, and this may be of anthropologic importance.

Conjectural statements with cultural connotations should be avoided by the zoologist, but all biologic facts which might be of interest to the archeologist should be mentioned. Especially important for consideration are the biologic facts or inferences which indicate former environmental conditions. Species which have a narrow environmental or ecologic range (steno-ecologic species) as contrasted with species which have broad environmental limits (eury-ecologic species), should receive special attention in discussion of their ecologic preferences or restrictions. Much work on the literature is necessary to gain an accurate idea of the ecology of the species involved, in order to formulate the interpretations. Knowledge of the ecology of steno-ecologic species which are absent, but expected, is of value in indicating certain environmental conditions of the site-area which are (or were) unfavorable to these species.

With time, and with an increased number of thorough reports on archeologic findings in zoology (and botany, as well), a better picture of former ecology and of subsequent ecologic successions for certain regions will be available This may be of importance in future judgments on land management involving problems of agriculture, fish, game, and general plant cover.

Future work of identifying large numbers of mammal bones may stimulate, and subsequently utilize, statistical studies of interspecific skeletal characters, especially of long bones. This applies also to intraspecific (subspecific) skeletal characters.

11. The zoologic facts of interest should be published in a zoologic journal. This gives ready access of the information to other zoologists and they will be enabled thereby to interpret related zoogeographic problems (which always have a time factor), or to make any other historic deductions, or to fill in the known ranges of common species. When incorporated in an archeologic report as an appendix, such information often duplicates statements made by the archeologist, and moreover is often overlooked by the zoologists. There need be little repetition in separate reports of the archeologist and the zoologist.

SUMMARY

Archeologic collections of mammal bones constitute a faunal assemblage from a certain locality at an earlier time than the present, and they should be considered as worthy of serious study, especially by local state, city, or university museums, which usually have or can make better collections of the local fauna than the larger "national" museums.

Facts of interest to archeologists and zoologists come from such studies, e.g. faunal time-markers, extensions of species distribution in the past or subsequently, unknown subspecies or even species, hitherto unrecognized characters which distinguish one species from another related one, application of statistically determined skeletal differences to make identifications, and indications of ecologic and climatic conditions during the ancient deposition of the cultural remains with application of these findings to studies of long-range ecologic succession or cycles of succession.

To obtain information from the collection of mammal-bones, on the above (and other) points of interest, a procedure of work is necessary, just as the design of an experiment is necessary. Such a procedure is outlined to allow for rapid and systematic identification, and for easy review of the critical material with preservation of the most important specimens for future reference and verification.

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A MEANS TO DISTINGUISH SKULLS OF COYOTES AND DOMESTIC DOGS

BY W. E HOWARD

Nearly every mammalogist and wildlifer is confronted at times with the task of deciding whether a certain skull is that of a coyote or domestic dog; and, certainly, often it is difficult or impossible to make a certain identification. By the technique described below it becomes possible to identify any skull by determining the ratio of two measurements; and this can be done with a pencil or a small stick if no ruler is available. The method has been tested on 194 skulls of known identity. The only exceptions encountered were the skulls of hybrids between domestic dog and coyote and two of fox terriers. The latter two were obviously much smaller than any coyote skull, and thus were not questionable.

Several early writers on the ancestry of domestic dogs, (Coues, 1873; and Packard, 1885), believed that the Indian dogs of North America were derived from tamed coyotes. Others considered that many of the domestic dogs in this continent were of coyote origin. Their opinions were based on consideration of external features without study of the skeletons. It is now generally agreed that the domestic dog of the caucasian is of Old World ancestry from wolves or jackals, or both. This does not necessarily imply that there is no coyote blood in any of the domestic dogs in North America, for hybrid matings between coyote (*Canis latrans*) and dog (*Canis familiaris*) are known (Dice, 1942). I have found no published record, however, that hybrids from a dog-coyote mating are fertile. Crosses between the wolf and dog are known to produce hybrids in which both sexes are fertile (Przibram, 1940, 3: 109).

Cope (1893) noted the absence of the first premolar in dogs and remarked upon the large size of the metaconid and the entoconid of the lower carnassial. Allen (1920) said that a large percentage of American native dogs lack the first premolar of the lower jaw. Malformations of the teeth seem to be more common in dogs than in coyotes. Allen found that domestic dogs and wolves are essentially alike in the cusp characters and in the proportions of the teeth, but on the average differ from coyotes and foxes in characters which are slight but appreciable on direct comparison. He stated further that dogs are more closely related to wolves than to coyotes as shown by several characters: (1) the shorter and narrower heel of the lower carnassial in proportion to the length and width of the

remaining part; (2) the general bluntness and plumpness of the premolar and molar teeth and their cusps; (3) the shorter and blunter canines; (4) the distinctive outward bend at the junction of the upper premolars and molars in the dog and wolf but not in the coyote; and (5) the presence of a minute second posterior

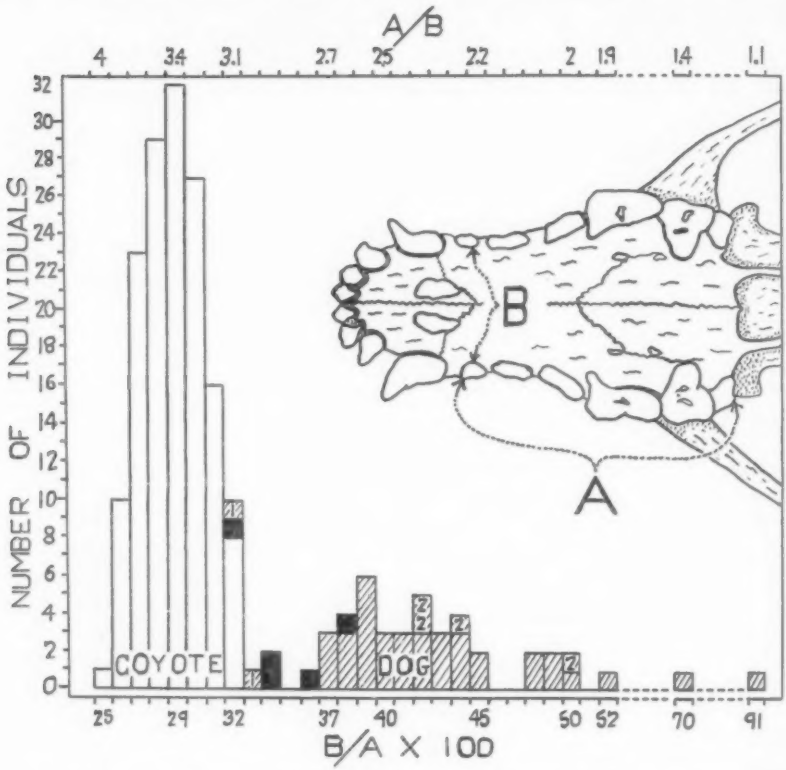

FIG. 1.—Ventral view of the forepart of a *Canis* skull; and distribution of B versus A ratios for skulls of 146 coyotes (unshaded), 43 domestic dogs (shaded), and 5 hybrids (solid black). Two fox terrier skulls (1) and four skulls from North American burial mounds (2) are indicated separately.

cusp in addition to the cingulum on the fourth upper premolar is characteristic of coyotes. Burt (1946: 61 and 62) distinguishes skulls of dogs and coyotes in his artificial key of the mammals of Michigan by the following method. For coyotes, the width of the rostrum is less than 18 per cent of greatest length of skull. Some dogs may fall in this size class. If they do, the width across the first upper molar (outside) will be more than 31 per cent and the width of the rostrum more than 18 per cent of greatest length of skull. Upper incisors are always closely set and

even. For dogs, the width of rostrum is more than 18 per cent of greatest length of skull and the upper incisors are usually with spaces between them.

All of the single characters which were tried to distinguish dogs and coyotes proved invalid when a large series of skulls was used. It became apparent, however, that the muzzles of all coyotes were longer and narrower than those of dogs; consequently a ratio incorporating this characteristic was used. This index or ratio (bottom of Fig. 1) is the *palatal width* (between inner margins of alveoli of upper, first premolars) *divided by the length of the upper molar tooth-row* (anterior margin of alveolus of first premolar to the posterior margin of the last molar alveolus).

To identify a skull in the field and without a ruler, the reciprocal of this ratio is used (top of Fig. 1); the length of the upper molar tooth-row divided by palatal width between the upper first premolars. If the molar tooth-row is 3.1 or more times that of the palatal width, the specimen is a coyote; but if it is less than 2.7 times it is a dog. Skulls can be differentiated even when flesh is present.

For most of the domestic dog skulls measured, breeds were unknown. In addition to those included in Figure 1, some individual skulls of known breeds had B/A × 100 ratios as follows: police dog, 38; greyhound, 39; and bull dog, 91. Six wolf skulls had ratios of 33, 34, 35, 35, 35, and 35, respectively.

Acknowledgments are due William H. Burt and Emmet T. Hooper for permission to use specimens in the Museum of Zoology, University of Michigan, and for their encouragement in this study. Dog skulls in the Museum of Vertebrate Zoology, University of California, were made available by Seth B. Benson.

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RATE OF PENETRATION OF A PORCUPINE SPINE

By Albert R. Shadle and Donald Po-Chedley

During the examination of one of the porcupines in the vivarium of the University of Buffalo, the animal became excited, and, as a result of its struggle, fell backwards from the porcelain top of the table. She fell upon the antero-lateral surface of the junior author's right leg, embedding her spines primarily in the belly of the tibialis anterior muscle. Apparently the mid-sacral region of the animal's back made contact with the leg, for the embedded quills were similar in length, diameter, and color to the spines in that area. The force of the fall of the 12.5-pound animal drove its quills through the heavy laboratory coat, the trousers, and deeply into the flesh of the leg. This incident occurred at about 10:50 A.M., January 20, 1947.

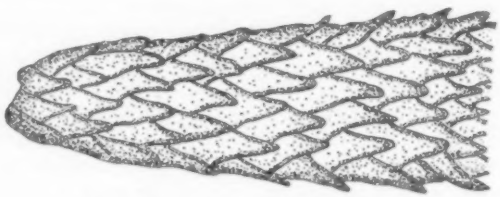

Fig. 1.—Porcupine quill, tip, about 45×

The extent of quill penetration varied from a slight perforation of the skin, by the tip of the spines, to an extreme initial penetration of 16 mm. into the leg. The thumb and forefinger were used to remove most of the quills, but pliers were necessary for the removal of the most deeply embedded ones. Seventy-nine quills had penetrated the skin deeply enough to secure firm anchorage. Seventy-eight spines were immediately removed, but one spine was so deeply buried that only the root-bulb remained exposed. The act of removing one of the adjacent quills lifted the skin at that point to the extent that the root of this deeply embedded quill disappeared completely beneath the skin surface. Since this one spine was now no longer visible, nothing further was done at the time to remove it.

Within a few minutes after the quills were removed, petechiae of varying diameters developed on the skin surface. Quills which had made only a shallow penetration produced individual red spots less than 2 mm. in diameter, or none at all, and the removal of these spines caused only slight local discomfort. The petechiae from the deeply embedded quills produced radiating pain which spread as far as the toes, and the petechiae produced by these spines were 2 mm. to 3 mm. in diameter.

The reactions of the tissues to this injury resulted in a slight swelling accompanied by a soreness and stiffening of the muscle in the affected area. There was no marked infection nor any evidence of a purulent condition. The follow-

ing morning the petechiae were scarcely visible, and the soreness was reduced to a very small area—the section where the one quill was still completely buried in the flesh.

At about 5:20 P.M., on January 21, 30.5 hours after the accident, the tip of this single remaining quill was observed protruding through the skin at a point 15 mm. mesad from the ridge of the tibia. It had worked its way from the point of entry, apparently through muscle tissue, across the long axis of the leg to its point of exit opposite the mesal face of the tibia. This quill was 18 mm. long and measured 0.75 mm. at the widest section of the shaft. The distal 11 mm. of the spine show clearly the retrorse scales as illustrated by the drawing (Fig. 1).

The straight distance between the points of entry and exit of the quill was 48 mm. This represents a minimum distance traveled by the quill, assuming that it progressed along a more or less straight path. In the porcupine's fall, 16 mm. of the quill were initially driven directly into the flesh. The contraction of the muscle, in contact with the scales on the embedded spine, drew the spine a distance of 32 mm. (1.05 mm. per hour) through the tissue to the point of emergence. This is in close accord with the report by Shadle (Jour. Mamm., 28: 180–81, 1947) concerning a 7-mm. quill fragment which had traveled 42 mm. through the skin and muscle of his arm in 42 to 45 hours, a rate of approximately 1 mm. per hour, or about one inch per day.

There was only slight discomfort resulting from the actual passage of the quill through the tissue. Shadle (*op. cit.*) also felt only occasional slight pricking sensations during the hours when the spine was progressing through his muscle.

A similar incident was cited by Taylor (Biol. Sci. Bull. 3, Univ. Ariz. Bull., vol. 6, no. 5: 1–177, 1935), in which an observer broke off a portion of a quill in his leg. Since he was unable to extricate this fragment, it remained in the flesh of the leg, and after six days it had worked its way through the tissues to the point at which it emerged. No information was given on the rate of penetration nor the distance traveled through the leg by this quill fragment.

Biology Dept., Univ. of Buffalo, Buffalo 14, N. Y. *Received August 5, 1948.*

THE BEAVER IN OHIO

By Floyd B. Chapman

The beaver (*Castor canadensis*), once common to abundant and widely distributed in Ohio, was exterminated by 1830. During the past eleven years, however, beavers have become re-established in the state, evidently spreading from Michigan and Pennsylvania and from introductions made by sportsmens' organizations. Some have escaped from fur farms.

What is believed to have been the first evidence of beavers in Ohio during the twentieth century was a number of peeled aspen trees found on the Ohio side of the Pymatuning Reservoir in Ashtabula County on or about May 15, 1936, by the writer and Lawrence E. Hicks. In the same year, a lone beaver established itself on McMahan Creek, Belmont County. Since then there have been a number of reports of beavers, including animals killed on the highways, wandering individuals, or those in established colonies. Late in 1946, the Ohio Division of Conservation and Natural Resources received the first complaint of beaver damage—the flooding of potential pasture and cropland and menace to a bridge at Guilford Lake, Columbiana County. This prompted a survey to determine the number of existing colonies, recent records of beavers in Ohio, the principal foods, nature and extent of damage, if any, and other information useful in the management of the species.

On February 7, 1947, each conservation officer was sent a questionnaire and his co-operation was solicited in obtaining all possible information on beavers in the two-month period that followed. The writer has personally checked some but not all of the colonies reported by the conservation officers and has reviewed the published records of Ohio beavers, most of which have appeared in the *Ohio Conservation Bulletin*, monthly publication of the Conservation Division.

The writer wishes to express his appreciation to the field men of the Conservation Division and to others who co-operated in making the survey.

DISCUSSION

In 1947, beavers occurred in eleven Ohio counties—Mahoning, Ashtabula, Portage, Williams, Defiance, Auglaize, Jefferson, Carroll, Trumbull, Harrison, and Columbiana. Three of these counties, Defiance, Williams, and Auglaize, are in the northwestern Ohio "corn belt;" the remainder are along the eastern border. Most of the colonies in the eastern counties undoubtedly originated in Pennsylvania, although some individuals have probably escaped from fur-farming enterprises. Those in northwestern Ohio have evidently entered the state from Michigan.

Twenty-five colonies were reported in the 1947 survey. On the basis of four individuals per colony there would be one hundred beavers in the state. In addition to the known active colonies in 1947, seven additional counties, six in eastern and one in northwestern Ohio, have had beaver colonies or some evidence of the species has been reported from them during the past six years. These counties are Cuyahoga, Guernsey, Muskingum, Belmont, Monroe, Washington, and Lucas.

A summary of all active colonies reported on the 1947 survey is given in Table 1. Records of individual beavers prior to and during 1947, and colonies, both active and inactive, reported in the 1947 survey, are shown in Figure 1.

TABLE 1.—*Active beaver colonies in Ohio—1947*

COUNTY	TOWNSHIP	LOCATION
Ashtabula	Pierpont	Hall Farm
	Pierpont	C. Partsch Farm
	Williamsfield	Pymatuning State Park
Auglaize	Noble	St. Marys River
Carroll	Lee	Grant George Farm
Columbiana	Lisbon	Harty Farm
	Lisbon	County Home
	Lisbon	Allison Farm
	Lisbon	Guilford Lake
	Hanover	State Property
	West	Patterson Farm
	St. Clair	Valrey Farm
	Washington	Dezelum Farm
	Yellow Creek	City of Wellsville
Defiance	Milford	St. Joseph River
		Guy Cape Farm
Harrison	Short Creek	Short Creek
Jefferson	Wayne	Between spoil banks
	Smithfield	Short Creek near Adena
Mahoning	Jackson	Meander Lake
	Green	Little Beaver Creek
Portage	Franklin	Paul Brehm Farm
Trumbull	Hartford	Boyd-Hamilton Estate
	Hartford	Boyd-Hamilton Estate
	Hartford	Smith Farm
Williams	Bridgewater	St. Joseph River

As reported by the field men, and checked in subsequent investigations, the important foods of Ohio beavers are wild apple trees, quaking aspen, domestic fruit trees, cottonwood, elm, willows, smooth alder, and corn. It is significant that the only reports on corn utilization are from Williams and Defiance counties in the Ohio "corn belt." In a few instances beavers are cutting timber of com-

mercial value, but the landowners have shown considerable pride in having a beaver colony and have ignored the damage. This attitude has undoubtedly reduced poaching to a minimum. There is no open season on beavers in Ohio at the present time.

FIG. 1.—Recent records of the beaver in Ohio

Dispersal of beavers in Ohio is occurring along the larger creeks and rivers, principally the St. Joseph River in northwestern Ohio and the Ohio River and tributaries in eastern Ohio.

RECORDS OF OHIO BEAVERS (1936–1947)

The past history and present status of beavers in each of the counties from which they have been reported follows:

Ashtabula County.—The writer and Lawrence E. Hicks probably found the first evidence

of the re-establishment of beavers in Ohio at Pymatuning State Park, Ashtabula County, on or about May 15, 1936. In 1942 (Ohio Cons. Bull., 6: 24, Aug., 1942), two beavers were captured while fighting dogs on the Chester Paul farm at Cherry Valley. These animals were kept for display purposes. In 1944, beavers were reported on a small creek in Monroe Township, a few miles south of Conneaut (Ohio Cons. Bull., 8: 19, Apr., 1944). Mr. C. E. Webb reported another beaver dam in this county in 1946, located on the Charles Partsch farm a few miles south of Pierpont (Ohio Cons. Bull., 10: 25, Dec., 1946). Another report by an anonymous author was published in the May, 1946, issue of the Ohio Conservation Bulletin, but the location was not disclosed.

In the 1947 survey three beaver colonies were present in the county, one in Pymatuning State Park nearly one mile from the site located in 1936, another on the Partsch farm several hundred feet from the colony reported by Webb in 1946, and the third on the Hall farm in Pierpont Township.

Auglaize County.—An active colony on the St. Marys River, Noble Township, was reported on the survey. There are apparently no other recent records for the county.

Belmont County.—A lone beaver appeared on McMahan Creek in 1936, and a colony became established there the following year. Beavers were observed at this spot until 1939. The animals fed on willows and elms (Ohio Cons. Bull., 3: 5, July, 1939). In 1940, a group of Belmont County sportsmen prevailed upon the Conservation Division to obtain a pair of beavers from the New York Conservation Department. These animals, trapped in the Adirondacks, were released on the south fork of Captina Creek. They soon disappeared from the county, but possibly the present colonies or individual beavers in Jefferson County originated from this release. No beavers were reported on the 1947 survey.

Carroll County.—There was formerly a beaver colony in an artificial lake on the Kilgore farm in Lee Township, but this colony was inactive in 1947. The only active colony reported on the survey was the one on the Grant George farm in Lee Township, five miles east of Carrollton and two miles south of Scroggsfield. At this location, they were cutting some timber of little value and the landowner did not object.

Columbiana County.—Nine active colonies were reported in 1947. Beavers have been active around Guilford Lake, Center Township, since about 1941. The history and development of this colony are well documented by Bob Wylie (Ohio Cons. Bull., 6: 1, June, 1942). These beavers are believed to have come from a farm nearly twenty-five miles away, where stock had been obtained from Michigan. This fur farmer is said to have lost nearly fifty beavers which escaped from confinement. At Guilford Lake, as many as three beavers could be seen at one time according to the above cited report. In the sping of 1947 the dams at this colony were dynamited by local disgruntled residents who claimed the beavers were flooding potential pasture and cropland. The land has not since been put to any use and the beavers, if still alive, must have moved some distance away, for they are not now present at Guilford Lake.

No information is available on the development and past history of the eight additional colonies reported on the survey.

Cuyahoga County.—A specimen in the Cleveland Museum of Natural History was run over by an auto in 1939 in South Chagrin Metropolitan Park (Bole and Moulthrop, Sci. Pub. Cleveland Mus. Nat. Hist., 5: 141–42, 1942). At about the same time beavers were said to be ". . . reappearing in northeastern Ohio, particularly along the Chagrin River." There are apparently no additional recent records and no colonies were reported on the survey.

Defiance County.—Beavers appeared in Defiance County about March, 1946, on the St. Joseph River in Milford Township, and were recorded on the Guy Cape farm during the survey. Extensive damage to corn was experienced by Mr. Cape in the fall of 1947.

Guernsey County.—There was formerly a colony in this county, but the exact location was unknown to the conservation officer. The beavers disappeared in 1945.

Harrison County.—A colony existed in 1944, but had disappeared before the 1947 survey. The location is unknown. Late in 1947, reports were received of a beaver on the Upper

Fork of Short Creek (close to the Jefferson County line and not far removed from the colony near Adena, Jefferson County), another on Flag Run, and still another killed on a highway. Evidently beavers were re-established in this county in 1947, and there is considered to be a colony in Short Creek Township.

Jefferson County.—Two active colonies were reported in 1947. One of these has existed since the spring of 1945 between strip mine spoil banks in Wayne Township. There is said to be four beavers in this colony. The second active colony is on short Creek near Ramsey and Adena in Smithfield Township (Ohio Cons. Bull., 11: 30, Nov., 1947). A single beaver was discovered in the cellar of a house in Brush Creek Township in the spring of 1947 (*Ibid.*, 11: 24, July, 1947). It was released on Brush Creek Wildlife Restoration Area by conservation officer Ray Starr. The possibility of there being inactive colonies has not been investigated.

Lucas County.—According to Mr. F. C. Bridenbaugh of the Toledo Metropolitan Park Board (personal communication dated Sept. 3, 1947), in the autumn of 1942 a pair of surplus beavers from the Toledo Zoo was released in Oak Openings Park. "Immediately upon getting their liberty they got busy, cut down a large number of small poplars and built a dam at the spillway at the end of a small artificial lake. However, they soon proved to be great roamers and at one time were observed on a small creek south of Brailey, six miles from the Park. They would absent themselves from the Park for months at a time, but they always returned. Two young were born in the spring of 1943. They were observed by a very few persons and were never seen by anyone after the half-grown stage. No young were ever observed in 1944 or 1945. The last time that anyone saw either of the old beavers was on a crisp November evening (1945) when a Miss Joan Ort and Mr. Perry Howell, assistant custodian of the park, saw the animal by bright moonlight, playing in the water. Both parties were familiar with beavers and were certain of what they saw." Beavers were not reported in Lucas County on the 1947 survey.

Mahoning County.—The first mention of the present beaver colony in Meander Reservoir was made in the Ohio Conservation Bulletin (p. 24), October, 1946, issue. According to this report, beavers were first seen there on July 28, 1946. The writer found these animals to be feeding almost exclusively on smooth alder (*Alnus rugosa*). No evidence of lodges or dams was found.

An additional colony on the Moore farm, Little Beaver Creek, Green Township, was reported on the survey. There are now two active colonies in Mahoning County.

Monroe County.—In this county there was, about six years ago (1941), a colony of beavers on Opossum Creek. This colony was inactive in 1947.

Muskingum County.—A beaver colony was described in the December, 1942, issue of the Ohio Conservation Bulletin under the title "Beavers as water conservationists." These beavers had built two dams and were working on a third on Guyst Fork of Meigs Creek near Museville. There were at least four beavers present and a refuge was established around the colony. This colony was apparently inactive in 1947 and no additional colonies were reported.

Portage County.—Only one active colony was reported in 1947 and none are known previous to that date. The present colony is between Twin Lakes and Lake Rockwell in Franklin Township on the Paul Brehm property.

Trumbull County.—Three active colonies were reported in 1947, all in Hartford Township. Two are on the Boyd-Hamilton estate, a large semi-wilderness tract of land lying on Yankee Run. On the Smith farm nearby no dams have been located, but a considerable amount of cutting has been noted by conservation officer Minyoung.

Washington County.—Conservation officer Wehrs reported having seen a beaver about four years ago (1943) at Lowell on the Muskingum River. He believes this animal may have worked its way up the river and was eventually one of those that settled on Meigs Creek in Muskingum County.

Williams County.—One active colony was reported in 1947. An estimated fifteen beavers live in this colony on the West Branch of the St. Joseph River, six miles northwest of Mont-

pelier on State Route 567. A dam thirty-five feet long was constructed (Geedy, L. B., Ohio Cons. Bull., 8: 24, Dec., 1944). This colony was established in 1944 or earlier.

SUMMARY

The beaver was completely exterminated in Ohio by 1830, but in 1947 there were active colonies in eleven counties. Seven additional counties had beavers during the past few years, but no active colonies were reported from them in 1947. There are at present twenty-five active colonies containing from 100 to 125 beavers. The first known occurrence in the twentieth century was the almost simultaneous appearance of beavers in Ashtabula and Belmont counties in 1936. Columbiana County has the greatest number of colonies at present, with nine or more, all of which have developed in the past six years.

Ohio Division of Conservation and Natural Resources, Columbus, Ohio. Received March 8, 1948.

SMALL MAMMALS OF THE HIGHLANDS (NORTH CAROLINA) PLATEAU

By Eugene P. Odum

A field study of the smaller mammals of the Highlands Plateau was undertaken as part of a broad program of research on the comparative vertebrate ecology of Mountains, Piedmont, and Coastal Plain of the southeastern United States. In addition to the gathering of data from the regions generally, more intensive work in selected "sample" or "study" areas within each of the three great regions is being carried out. The Highlands Plateau area has been selected as one of the mountain study areas because conditions here seem representative of the southern end of the Appalachian backbone and because of the facilities offered by the unique Highlands Museum and Biological Laboratory. The present paper summarizes what is now known of the occurrence and distribution of mammals of the area, necessary prerequisite knowledge for work of an ecological nature.

This investigation was aided by grants from the Minnie D. Warren and Col. and Mrs. John S. Sewell Funds, administered by the Highlands Biological Laboratory.

SCOPE AND METHODS OF STUDY

Field work at Highlands was conducted during the following periods: June 17–30, 1946; September 24–25 and October 26–27, 1946; May 31–June 1 and June 9–July 4, 1947; June 7–22, 1948, a total of about fifty-five nights of trapping. Essentially, this paper is based on the study of mammals in June of three successive years, together with data obtained by other biologists who have worked in the area.

During June, 1947 and 1948, I was fortunate in having, as a full-time student assistant, Mr. H. V. Autry, who helped very materially in setting traps and preparation of specimens. During the first two years mammal work was somewhat

secondary to a study of bird populations, but in 1948, with bird work largely completed, we devoted nearly full time to mammals.

Most of the collecting was done with ordinary commercial mouse and rat traps set for one night or longer. No. 0 steel traps, Sherman and home-made live traps, and large Havahart metal live traps were also used. A few mammals were shot, and several found dead on highways were in sufficiently good condition to preserve. Most trapping was at random and qualitative only, but in 1948 six standardized trap lines were run to obtain some idea of relative abundance in three major habitats.

No attempt was made to collect or obtain information on mammals larger than fox-size. Bear and deer are reported to occur, although not commonly. Bobcats are frequently reported by local people and are undoubtedly common in certain sections. Our data on bats are meager since we had little opportunity to shoot them and the region lacks large caves where certain species might be found.

Mammals occurring in the valleys (such as at Franklin, N. C. or Clayton, Ga.) or below 3000 feet in altitude are not included in the present paper, which deals with the mammals of a single major altitudinal and biotic zone. An altitude of 3000 feet roughly marks the boundaries of plateau and the adjacent high coves, and generally divides northern and southern animals. Ninety per cent of collecting was done between altitudes of 3400 and 4200 feet.

Of the 175 specimens taken, 94 were preserved as study skins and skulls, three as skulls only, and seven as alcoholics. Most of the specimens not saved (chiefly *Peromyscus*, *Blarina*, and *Clethrionomys*) were measured and weighed and this data is included in the annotated list which follows. Unless otherwise stated all specimens are in the University of Georgia collection.

ACKNOWLEDGMENTS

In addition to the assistance given by Mr. H. V. Autry, as previously acknowledged, I am indebted to Highlands Biological Laboratory and its resident director, Miss Thelma Howell, for providing the opportunity to conduct the work, and to various Highlands' people and workers at the Laboratory as follows: Mr. Henry Wright, who owns some of the best undisturbed areas of the region, for permission to work on his property; Mr. Ben Williams, owner of Sky-Winding Farm near Scaly, who took great interest in our work and allowed us to trap extensively on his property; Mr. Tuck Burnette, who lives on Mr. Williams' farm and who supplied us with much information and our only specimen of *Zapus*; Mr. Dwight Hardin for information and specimens from Horse Cove; Dr. J. M. Valentine, who, as year around resident of Highlands, has kindly turned over to us several specimens which he picked up incidental to his research on the Coleoptera. Dr. J. J. Friauf and Dr. J. Y. Peary obtained several good specimens in 1947, after our departure. Finally, I am especially indebted to Dr. H. H. T. Jackson who has examined many of the specimens obtained and who has made the subspecific determinations as listed in this paper.

PREVIOUS WORK AT HIGHLANDS

In common with southeastern United States generally, the Highlands area has received comparatively little attention from mammalogists. Early explorers and collectors have visited the area from time to time. There are a number of specimens in the National Museum from Highlands, taken prior to 1900 by William Brewster, C. L. Boynton, and others. Highlands is the type locality for the Alleghenian red squirrel, *Tamiasciurus hudsonicus abieticola*, the type specimen having been collected by Boynton in 1886. In June, 1930, Arthur H. Howell spent a few days in the "Primeval Forest" at Highlands and collected thirteen specimens of seven species, one of which, *Neotoma floridana haematoreia*, we have not found in our work. Mr. E. B. Chamberlain collected specimens of seven or eight species during vacation periods in 1930–32; these specimens are in the Charleston Museum. The Highlands Museum and Weyman Biological Laboratory (established in 1927 and 1930, respectively) keep a file of biota cards containing records of all species of various plant and animal groups known to occur in the region. At the beginning of our work only fourteen species of mammals were listed on these cards, which included records from Howell and Chamberlain and records obtained incidentally by workers in other fields.

THE HIGHLANDS PLATEAU

Highlands lies on the main Blue Ridge of the Appalachian Mountains only a few miles from both Georgia and South Carolina (Fig. 1). The Highlands Plateau, an area of about 75 square miles with an average elevation of better than 4000 ft., is the last high plateau area southward. The Blue Ridge extends southward some distance into Georgia as a rugged ridge (with spurs and cross ridges) with a number of peaks between 4000 and 5000 feet elevation, but there are no extensive, relatively flat areas at high elevations. Consequently, boreal communities are fragmentary and scattered south of Highlands, which thus occupies a strategic position near the end of the mountain salient which "funnels northern species into the heart of the southland," as it were. One gets an especially good idea of closeness of northern and southern environments in approaching Highlands from Walhalla, South Carolina. The Blue Ridge is clearly seen rising abruptly from Piedmont Plateau and one climbs from 1000 feet to nearly 4000 feet in a very few minutes by automobile.

The approximate extent of plateau and the collecting localities are shown in Figure 1. Unlike most mountain towns, which are in the valleys, Highlands is up on the plateau, and is said to be the highest incorporated town in Eastern North America. "Main street" has an elevation of 3835 feet, and ridges within the town limits rise up to better than 4200 feet. The highest points on the plateau are Satula Mountain, 4560 feet, and Shortoff Mt., 5054 feet.

As would be expected, the summer climate of the plateau is cool and moist and the winters may be severe with occasional periods of heavy snowfall. The rainfall is relatively heavy, 60 to 80 inches, almost as great as in the Great Smoky Mountains. The Highlands area differs from the Smokies in that there

is no spruce zone. The peaks are covered with a deciduous, largely oak-chestnut, forest which forms one of the principal climaxes (probably the climatic climax) of the region. The real boreal or northern coniferous forest communities are not on the peaks, but in the moist areas along the streams and on the high, level parts of the plateau. Hemlock is the chief dominant of this, the second major climax (perhaps a post-climax), with white pine and northern hardwoods (yellow and black birch, maple, basswood, black cherry, northern oaks, etc.) prominent. Great masses of Rhododendron and Kalmia (Mountain Laurel)

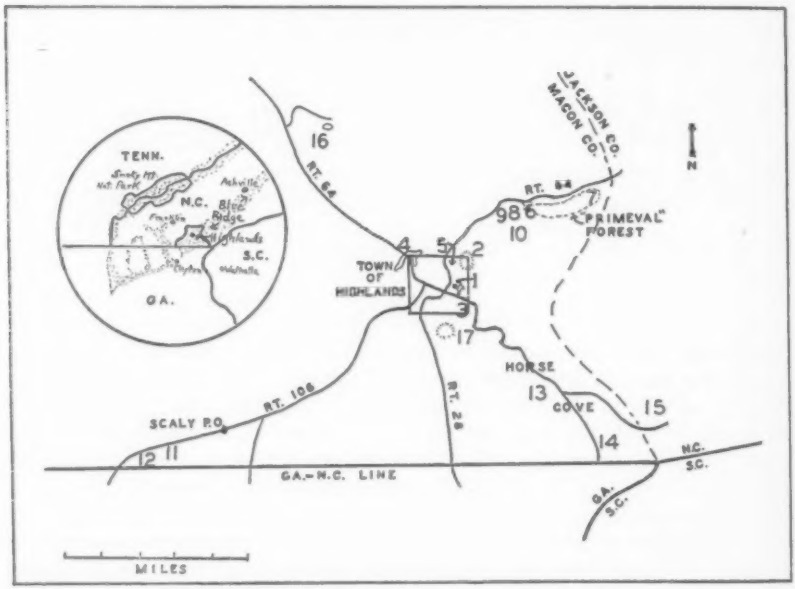

FIG. 1.—Sketch map of the Highlands vicinity showing roads and numbered collecting localities as referred to in the text. Insert shows geographical position of Highlands Plateau and its relation to the main Blue Ridge and Great Smoky Mountains.

are characteristic of the understory of these moist forests just as the Azalias are the crowning glory of drier oak-chestnut. The wealth of flora has made Highlands a mecca for botanists for many years. There was an extensive area of virgin hemlock, with trees four feet and more in diameter and 400 or more years old, known as the "Primeval Forest" or "Ravenal's Woods," located four miles east of Highlands, paralleling highway 64. Under pressure of wartime high prices this magnificent forest was logged, a bad mistake from many angles. Remnants of this forest remain (Pl. I, lower) and there are, of course, many more limited virgin and second growth stands of hemlock scattered over the area. While the region as a whole is heavily forested, the forests are not unbroken and free from human habitation as in the Smokies or wilder parts of the

PLATE I

UPPER: Locality 8, a small bog at 4000 feet elevation. The invading trees in the background are white pines. *Synaptomys*, *Microtus*, and a single individual of *Sorex fumeus* were taken within the area shown in the photograph.

LOWER: Locality no. 6, a remnant of the once extensive virgin hemlock forest. *Peromyscus maniculatus*, *Clethrionomys*, *Tamiasciurus*, *Sorex fumeus*, and *Sorex cinereus* were taken here.

Blue Ridge to the north. Good roads criss-cross the region, and small clearings, farms, and cabins are to be found throughout. Since the town of Highlands is largely residential with summer homes scattered through the forests, which have largely been undisturbed in recent years, many good habitats for mammals are found within the town limits.

TABLE 1.—*Collecting localities with habitat and altitude*

LOCALITY	HABITAT	ALTITUDE
		feet
1. Vicinity of Laboratory and Lake Ravenal	Mature second-growth, hemlock-white pine-northern hardwood	3900
2. Bearpen Mountain	Oak-chestnut with hemlock in ravines	3900 to 4200
3. Wolf Ridge	Oak-chestnut	4100
4. Franklin Road	Second-growth oak-chestnut	3700
5. Willow creek, Edwards Lake, Kelsey trail	Hemlock-hardwood forest	3900
6. Virgin hemlock, Wright tract of 10 acres, ¼ mi. east on Rt. 64	Virgin hemlock	4000
7. Logged hemlock extending from no. 4 to Jackson Co. line	All large trees removed in 1945–6; mass of Rhododendron, and other shrubs and understory trees, with logging debris	4120
8. Small bog and meadow on old Wright farm	Sphagnum and sedges, grading into dry grass	4000
9. Bushy fields on old Wright farm	Old fields and pastures overgrown with Rubus, black locust, etc.	4000
10. Mature oak-chestnut, Wright place	Undisturbed forest except for removal of some dead chestnut	4100
11. Ben Williams' place near Scaly	Orchards, farm and second-growth hardwoods	3450
12. Fields at Burnette's Store, Williams' place near Ga. line	Heavy grass, mixed cultivated and wild along stream	3200
13. Horse Cove bog	Wet meadow with some sphagnum	3000
14. Dwight Harden Farm, Horse Cove	Small cultivated valley	2700
15. Granite "City," Horse Cove	Outcrop of hugh boulders on wooded slope	3100
16. Dry Falls and Cliffside Park	Second-growth oak-chestnut with white pine	3500 to 3600
17. Satula Mt.	Oak-chestnut with hemlock	4500 to 5000

PRINCIPAL COLLECTING LOCALITIES

In Table 1, the chief collecting localities are listed with altitude and habitat. For the most part altitudes were checked directly with a Taylor altimeter. Numbers as listed therein are used in the annotated list to indicate exact collection locations for different species for the benefit of subsequent workers in the area. The first five localities are inside the town limits of Highlands.

THE MAMMALIAN FAUNA

The mammalian fauna is distinctly northern. Except for the fact that different races are often involved, the list of species could well pass for that of some locality in New England. *Peromyscus nuttalli*, *Didelphis*, and *Spilogale*, which occur at high elevations on the plateau, and *Sigmodon*, which reaches the high coves, are the chief distinctly southern elements of the area. We found no evidence that *Reithrodontomys*, *P. polionotus*, or *Cryptotis*, known to occur at very low elevations, are present above 3000 feet elevation.

As far as presently known, Highlands is the southernmost point (in eastern United States) in the range of the following species: *Synaptomys cooperi*, *Sorex cinereus*, and *Clethrionomys gapperi*. The following additional northern species are known to occur only sparingly or for a short distance south of Highlands (into Georgia or South Carolina): *Tamiasciurus hudsonicus*, *Napaeozapus insignis*, *Sorex fumeus*, and *Sylvilagus transitionalis*. Until recently, *Zapus* and *Microtus pennsylvanicus* were not known even as far south as Highlands, but both have been found in the Piedmont of Georgia (Petrides, 1948; Odum, 1948). Highlands is also the southern point in breeding ranges of several birds, notably red-breasted nuthatch, brown creeper, and golden-crowned kinglet.

Comparison of fauna at Highlands with that of the Smokies is of interest, especially since the latter area has been recently worked rather thoroughly by Komarek and Komarek (1938). The faunas appear to be largely the same. We have found nearly everything at Highlands which the Komareks found in the Smokies with two prominent exceptions: *Microtus chrotorrhinus* and *Parascalops breweri*. Further work, of course, may yet add these two species to the Highlands list. In general, species of field and forest edge habitat reach higher altitudes at Highlands than in the Smokies, undoubtly due to greater influence of man in the former region.

RELATIVE ABUNDANCE

No attempt has yet been made to study absolute abundance of mammals in the area; indeed, June is not a good time of the year for such work. However, some data on relative abundance may be of interest. Mice and shrews were scarce in 1946, trapping often proved discouraging with sets of fifty traps failing to yield a single specimen. Red squirrels, however, were numerous and noisy. The situation became progressively better during 1947 and 1948 for most forms, 1948 being by far the best year although red squirrels were notably scarce and silent. By dividing the total number of animals caught by the total number of traps set and converting to percentage, the relative abundance for the three years may be expressed as follows:

1946, 5.9 per cent; 1947, 7.0 per cent; 1948, 15.1 per cent

In 1948, a double trap-line of standardized type was run in each of three habitats at the seme altitude and within a mile of each other. The habitats were virgin hemlock, hemlock completely logged three years ago, and mature

oak-chestnut (areas 4, 5, and 8 listed above). Each line consisted of 60 traps set in groups of three at 25-foot intervals. Lines were run parallel to each other about 100 yards apart. At each station, traps were set carefully in burrows and other likely places and were left for three nights with resetting and baiting each day. All traps were set within a radius of five feet of the center of the station. Thus, there were 120 traps set in a comparable way in each habitat. The total catch is shown in Table 2. The greater abundance of animals in the moist forest communities as compared with dry ones is indicated by the data, as is also clearly indicated by random trapping. The almost identical results in logged forest (in which every large tree was removed) and the virgin forest is rather amazing and indicated that terrestrial mammals are

TABLE 2.—*Trapping records for three nights*

	VIRGIN HEMLOCK	LOGGED HEMLOCK	OAK-CHESTNUT
Peromyscus maniculatus nubiterrae	9	11	0
Clethrionomys gapperi carolinensis	7	6	0
Blarina brevicauda talpoides	2	2	0
Sorex cinereus cinereus	1	1	0
Sorex fumeus fumeus	1	1	1
Peromyscus nuttalli	1	1	0
Totals	21	22	1

persisting despite what would seem to be rather drastic changes. Further analysis of complete mammal populations and breeding bird populations of the virgin vs. logged areas will be made in a subsequent paper.

ACCOUNTS OF SPECIES

In the following annotated list the general status and habitat, as far as known, are given first, then specific data on specimens, measurements, and breeding. The locality numbers refer to the "Principal Collecting Localities" already listed. Data on measurements refer consecutively to the three standard measurements: total length of the animal in the flesh, tail, and hind foot. Weights were taken in the laboratory as soon as the animals were brought in from the field. Nomenclature follows that of Hamilton (1943).

Didelphis virginiana virginiana Kerr. Opossum.—Occurs at least to 4000 feet elevation, probably throughout the region, but most common in farming regions at lower elevations, judging from signs and the reports of local people. Definite records include: a skull found near the Laboratory in 1947 and a full grown male caught in a live trap in southwest section of Laboratory woods in 1948.

Scalopus aquaticus aquaticus (Linnaeus). Common mole.—Found throughout the region, but locally, judging from observed tunneling activity; most common in forest openings and in the vicinity of human habitations. As in other regions, this species is sometimes a nuisance on lawns and golf courses in Highlands and vicinity. One lawn we examined was heavily infested with "June bug" (*Allorina*) grubs and was literally riddled with mole tunnels, the animals evidently seeking grubs. The owner was attempting a sort of bio-

logical control of moles. He was spraying the lawn in an effort to prevent adult beetles from ovipositing and thus breaking the food chain with the hope of indirectly eliminating the moles!

Specimens.—Five; localities 1, 3, and 11.

Measurements.—Av., 2 males: 154, 26, 20; wt., 66.6 grams. One female: 145, 26, 20; wt., 64.0 grams.

Reproduction.—Female, collected June 23, 1947, contained two large embryos, near term, one in each uterine horn.

Condylura cristata (Linnaeus). Star-nosed mole.—Probably a fairly common animal in the area. The only one examined was collected by a cat, belonging to Miss Reba Bridges, about June 1, 1946. Although the animal had been dead several days, I was able to prepare a skin which is now in the Highlands Museum. Twice, a small, dark, long-tailed animal believed to have been this species was seen swimming in the small stream entering Lake Ravenal, once by Dr. J. J. Friauf in 1947 and once by H. V. Autry in 1948. Mr. H. C. Harbison is reported to have taken specimens at Highlands prior to 1908 (Brimley 1945).

Sorex cinereus cinereus Kerr. Cinereus shrew.—This is a species not previously recorded quite this far south (previous North Carolina records were from Roan Mountain, Smokies, and Henderson County, Brimley, 1945) and not, at present, known from any point south of the Highlands Plateau (assuming that *Sorex longirostris* is not conspecific with *Sorex cinereus*). Our data suggest that this species was not as common as *Sorex fumeus* during the years 1946–48.

Specimens.—Three (all males); all from mature forests at localities 1, 6, and 7.

Measurements.—Av., two males: 96, 43.5, 13.5; wt., 3.22 grams.

Sorex fumeus fumeus Miller. Smoky shrew.—Apparently well distributed over the Plateau; very rare in 1946 and 1947, more common in 1948 when five of the seven specimens were taken. While primarily an animal of the mature forests, one was trapped in a small bog in runways used by *Microtus* and *Synaptomys* (Pl. I upper) and one was taken on the grassy margin of a small lake.

Specimens.—Seven; localities 1, 5, 6, 7, 8, and 10.

Measurements.—Av., 6 adults: 116 (109–123), 48.5 (44–51), 14 (13–15); wt., 7.02 (6.35–9.86) grams.

Reproduction.—Two females, examined in June, were not breeding.

Blarina brevicauda talpoides (Gapper). Short-tailed shrew.—One of the commonest and certainly the most widely distributed small mammal of the region. As is usually the case with this ubiquitous animal, it was taken in nearly all the major habitats ranging from virgin hemlock to moist meadows. However, *Blarina* showed considerable preference for moist habitats during the summer, especially areas along streams in the mature forests where the majority of specimens were obtained. It was not taken in dry fields.

Specimens.—Thirty-one taken, nine preserved as skins and skulls.

Measurements.—Av., 15 males: 115 (100–122), 25 (18–28), 14.7 (12–16); wt., 18.4 (14.1–21.7) grams. Av., 7 females: 113 (107–125), 24 (19–28), 14.3 (13–15); wt., 15.3 (13.2–19.0) grams.

Reproduction.—None of the females examined in June were pregnant. A half-grown individual was taken alive June 18, 1948. Several other specimens were juveniles, probably born earlier in the spring.

Myotis lucifugus lucifugus (LeConte). Little brown bat.—This is probably a fairly common species in the area although we have only one specimen, obtained from underneath the tarpaper of an abandoned shed by Dr. J. J. Friauf in 1947.

Measurements.—male: 74, 26, 7, forearm 31, ear 12.5.

Eptesicus fuscus fuscus (Peale and Beauvois). Big brown bat.—This is the common bat encountered by people in summer homes and cabins where it frequently roosts during the day behind blinds, in crevices, attics, etc. At sundown it is frequently noted flying over the small lakes of the area.

Specimens.—Three males; from buildings in Highlands.

Measurements.—Av., 3 males: 107 (96–128), 42.7 (41–48), 11 (9–12), forearm 36 (31–46); wt., 12.2 (8.3–19.1) grams.

Corynorhinus macrotis (LeConte). Big-eared bat.—So far, only one record, a specimen taken by Dr. J. M. Valentine on Aug. 7, 1948, and sent to me preserved in alcohol. The bat was caught when it entered his home in Highlands, altitude 3850 feet.

Procyon lotor (Linnaeus). Raccoon.—This is a fairly common and well-distributed animal on the Plateau, judging from signs and reports of local people. One was observed briefly early one evening on the edge of Cliffside Lake, but no specimens have been taken.

Mustela frenata noveboracensis (Emmons). Long-tailed weasel.—We have but one specimen of this weasel, but have seen tracks and had a number of reports of weasels which probably refer to this species. Trappers take a few in the winter. Mr. Burnette told me that several years ago, in late spring, he plowed into the underground nest of a weasel which contained three young and an adult. The adult in defense of its nest actually tried to attack him.

Specimen.—One male; killed on highway 64 near locality 7; preserved as study skin.

Measurements.—Male: 419, 131, 45.

Spilogale putorius (Linnaeus). Spotted skunk.—Occurs to at least 3900 feet, but its status and abundance relative to *Mephitis* has not been determined.

Specimen.—One; caught in steel trap at locality 1. Skin and skull preserved, but no measurements taken.

Mephitis mephitis (Schreber). Striped skunk.—*Mephitis* was quite abundant in cultivated and abandoned fields in the Scaly region. In one field nearly every stone had been overturned, attesting to their activity, and the animals were seen foraging at dusk. Since no specimens were taken the subspecies occupying the Plateau yet remains to be determined.

Vulpes fulva (Desmarest). Red fox.—Although all our information is from secondary sources there can be little doubt that the red fox is native to the region, although not common. The heavily wooded nature of most of the Plateau is not conducive to a large population of this species. It is possible that red foxes introduced into adjacent regions may have reached the Plateau, although there is no direct evidence.

Urocyon cinereoargenteus cinereoargenteus (Schreber). Gray fox.—This is the common fox of the region, the species which is usually observed and captured by farmers and hunters. In 1946 I examined an occupied den located under a projecting rock ledge on a steep wooded hillside. In June, 1948, two young fox pups were exhibited in Highlands. The parent and pups had been observed strolling in the daytime and the pups had been captured by hand.

Specimen.—One skull and tail from an individual found dead along a side road.

Marmota monax monax (Linnaeus). Woodchuck (Ground hog).—Woodchucks are common in the mountain valleys, the coves, and those parts of the Plateau where farming activities create openings in the woods. Except for one individual observed two miles west of town (altitude 3900) we did not observe it in the vicinity of Highlands or the high areas to the east. Hunting and digging out woodchucks with dogs is considered something of a sport by some of the local people.

Specimen.—One male; locality 14.

Measurements.—450, 120, 80.

Tamias striatus striatus (Linnaeus). Eastern chipmunk.—Locally abundant throughout the region. Chipmunks were conspicuous around cottages in Highlands, in the vicinity of the Laboratory, and in forests and forest edges east of town. They did not seem to be as common west and south of town. On June 15, 1947, while working in the Laboratory, loud squeals outside attracted my attention; on investigation I found a chipmunk attacking a young New England cottontail, only a little larger than itself. The chipmunk would rush up, grab the rabbit by its hind legs and chew a few seconds, and then let go. This was repeated several times, the rabbit squealed loudly, but made no attempt to defend itself or run away. When rescued, the hind legs of the rabbit had been badly cut up, but it was not otherwise injured.

Specimens.—Five; localities 1, 4, and 6. Four additional specimens were taken by Howell in 1930, and are in the National Museum.

Measurements.—One male: 221, 76, 36; wt., 105.8 grams. Av., 2 females: 241, 93, 36.5; wt., 97 grams.

Tamiasciurus hudsonicus abieticola (Howell). Red squirrel.—The red squirrel or "boomer," as it is universally known by the mountaineer, is locally abundant and noisily conspicuous on the Highlands Plateau where it seems to be almost exclusively an inhabitant of coniferous forests, rarely being seen in summer or fall far from hemlocks or white pines. It is not uncommon in the town of Highlands, and was especially abundant in 1946 and 1947 in the tracts of virgin hemlock. Just southwest of the Laboratory I examined two piles of cones, the accumulation of many years by red squirrels. Remains of white pine cones comprised the bulk of these piles with hemlock cones and hickory nuts quite evident. The animal has persisted in some numbers for at least two years in the logged "Primeval Forest" even though all large conifers were removed. In this area the red squirrels were observed running about in the smashed Rhododendron thickets, digging in soil in which still remained the seeds of conifers, and feeding on the fruits of Amelanchier and cherry which were produced in great abundance when these small trees were released from suppression after removal of the forest giants. As in the north, this species apparently undergoes a strong cyclic variation in abundance. After two years of abundance, the boomer was noticeably scarce and quiet in 1948, few being seen in the most favored habitats and none in the logged areas. It will be interesting to see if it continues to persist in the future in the latter areas.

Specimens.—Four; localities 1 and 6. The type specimen for this subspecies (Nat. Mus.) was taken by Boynton in 1886 and later described by Howell who also took three specimens at Highlands, one of which he presented to the Highlands Museum.

Measurements.—Av., 2 males: 316, 122, 45; wt., 216.6 grams. One female: 300, 120, 47; wt., 165.0 grams.

Sciurus carolinensis (Gmelin). Gray squirrel.—Apparently uncommon on higher portions of the Plateau, more common at lower elevations. In 1947 a pair was observed closely while feeding in a second-growth deciduous woods on a ridge above the "Primeval Forest," elevation about 4100 feet. No specimens have been taken.

Glaucomys volans saturatus (Howell). Southern flying squirrel.—Common throughout the vast forested areas where their high-pitched twitterings are a common sound at dusk in summer. Both outside nests, balls of vegetation in a crotch of a tree, and hollow stubs are utilized as dens in the summer. We have flushed animals from both situations. Sometimes flying squirrels take up residence in attics of cabins.

Specimen.—One; locality 1.

Measurements.—Female: 206, 87, 29.

Peromyscus maniculatus nubiterrae (Rhoads). Cloudland deer mouse.—This graceful mouse with the long, bushy-tipped and bicolor tail is probably the most common small mammal at higher elevations during most years, but it decreases in abundance abruptly at about 3400 feet, below which it is largely replaced by the next species. While it was taken in a variety of forest types and while it often enters houses, our data indicates that its focus of abundance lies in the moist hemlock-northern hardwood forest communities; 3100 feet is the lowest elevation at which we have trapped the cloudland deer mouse.

Specimens.—Forty, of which 16 were preserved; localities 1, 2, 3, 4, 5, 6, 7, 15, 16, 17.

Measurements.—Av., 24 males: 170 (152–189), 89 (79–102), 21 (19–22); wt., 16.1 (13.2–19.1) grams. Av., 15 females: 165 (150–187), 83 (69–90), 20.5 (19–22); wt., 14.6 (11.0–19.7). Males have relatively longer tails than do females in this region. The percentage of tail length to total length is 52.0 (48.2–65.2) for 24 males, 50.2 (46.0–54.2) for 15 females (these figures were obtained, not from averages above, but from tail-body percentages calculated for each specimen individually).

Reproduction.—Of a series of ten females examined in June, 1948, three were immature (gray pelage), six were adult, not pregnant but with placental scars, and one had three 4-mm. embryos in the uterus.

Peromyscus leucopus leucopus (Rafinesque). White-footed mouse.—The range of this species overlaps that of *maniculatus*, but it is much less common above 3600 feet. Occasional specimens were taken at 4000 feet, and Chamberlain took this species at an elevation of 4725 feet in 1931 (personal communication). Both *leucopus* and *nuttalli* (see below) occur higher in this region than they do in the more densely forested Smokies where neither was recorded above 2500 feet by the Komareks (1938). Our specimens were taken in forest-edge situations indicating that there is at least a partial habitat separation of *leucopus* and *maniculatus* at high elevations. At Granite "City," 3100 feet elevation, both species were trapped on the same rock ledges.

Specimens.—Seven, five preserved; localities 1, 2, 9, 11, and 15.

Measurements.—Av., 5 adults: 156 (152–160), 71 (64–81), 20.5 (19–22). Tail-total length percentage, 45.5.

Peromyscus nuttalli aureolus (Audubon and Bachman). Golden mouse.—The attractive golden mouse, although primarily a southern species, proved to be well distributed and locally common on the Plateau. Being more arboreal than other members of its genus it occurr ⁊ largely in forests and forest edges with heavy undergrowth, one even being taken in Rhododendron thickets of a virgin hemlock tract. The population at Highlands should probably be listed as intergrades between *P. n. nuttalli* and *P. n. aureolus*, especially since these races are not well marked. The Highlands series is indistinguishable in color from a series taken in the Georgia Piedmont (Athens), but average about 10 mm. longer in total length. On the other hand, Highlands specimens are about 10 mm. shorter than those from the Smokies which are listed as *P. n. nuttalli* by the Komareks (1938).

Specimens.—Eight; localities 1, 4, 5, 6, and 7.

Measurements.—Av., 6 adults: 169 (151–183), 74 (71–81), 18.5 (17–19); wt., 17.7 grams. Two immature specimens averaged: 141, 68, 18.5; wt., 12.6.

Reproduction.—Nest containing female and three young, June 15, locality 1.

Sigmodon hispidus hispidus (Say and Ord). Cotton rat.—This species barely reaches the lower limits of our somewhat arbitrarily designated region where it occurs in cultivated fields or hay meadows up to at least 3200 feet elevation. In 1948, Mr. Dwight Harden told us about some strange rats which had recently appeared on his farm in Horse Cove; these proved to be *Sigmodon*. Since local people in general seem to be entirely unfamiliar with this animal, it may be that it has only recently invaded the lower edge of the Plateau.

Specimens.—Four; localities 12 and 14.

Measurements.—Av., 3 large females: 255 (248–258), 88 (79–89), 30 (30–31); wt., 149.2 (138.4–160.3) grams. One young female: 175, 80, 25; wt., 31.3 grams.

Reproduction.—Two of the three adult females taken in June, 1948, contained young, nine well-developed embryos (June 15) in one case, four small ones in the other. The third female had eleven placental scars.

Neotoma floridana haematoreia (Howell). Wood rat.—The only record of this species is a specimen taken by Howell in the "Primeval Forest" in June, 1930. It is evident that the cliff-dwelling *Neotoma magister* has never reached the Highlands region or it would surely be found in such ideal habitat as Granite "City." Likewise, *Neotoma floridana* apparently has not taken to cliffs in this region, at least we found not the slightest sign of occupancy in what would seem to be ideal places.

Synaptomys cooperi stonei (Rhoads). Lemming vole.—Since this elusive animal is known from but comparatively few localities in the southern Appalachians, we were pleased to find it here and to thus extend its known range southward (Odum, 1948). The lemming vole was trapped in two widely separated wet meadows in surface runways also used by *Microtus* (Pl. I upper) and, in one case, in a runway six inches deep in a mass of wet sphagnum moss. Probable signs were also seen in a third bog.

Specimens.—Three (one in 1947 and two in 1948); localities 8 and 13.

Measurements.—Av., 2 females: 118, 18, 20; wt., 30.3 grams. One male: 127, 21, 9.

Clethrionomys gapperi carolinensis (Merriam). Red-backed vole.—A common species, but largely if not entirely restricted to the moist forests, especially the coniferous forest com-

munities. Along the boulder-strewn small streams and in the Rhododendron thickets it approached or exceeded the cloudland deer mouse in abundance. *Clethrionomys* appears to utilize the numerous natural crevices in its habitat rather than construct burrows of its own, and, as with other voles, it was often taken in traps during the daytime. We have no record of this species below 3600 feet, nor is it known to occur south of the Highlands Plateau.

Specimens.—Twenty-two, nine preserved; localities 1, 2, 5, 6, and 7.

Measurements.—Av., 9 males: 144 (129–156), 41 (38–44), 20 (18–21); wt., 28.2 (22.0–34.9) grams. Av., 9 females: 140 (130–158), 41 (37–45), 20 (19–21); wt., 23.9 (21.5–29.4).

Microtus pennsylvanicus pennsylvanicus (Ord). Meadow vole.—Occurs wherever there are meadows or bogs with a heavy growth of grasses and sedges, a habitat which is rather limited in mountainous regions. Quite rare in 1946 and 1947 when only one young animal was caught, it was more common in 1948, being obtained at one locality where results had been completely negative in previous years.

Specimens.—Nine; localities 8, 12, and Country Club area.

Measurements.—Av., 4 young males: 139, 37, 21; wt., 26.5 grams. One adult male: 157, 39, 21; wt., 41.1 grams. Two young females: 146, 39, 20; wt., 36.0 grams. Two adult females: 178, 46, 20; wt., 49.2 grams.

Pitymys pinetorum pinetorum (LeConte). Pine vole.—Locally common in the Scaly region and single specimens were taken at widely scattered points on the Plateau, mostly in forest-edge situations. At Williams' place several were taken from typical *Pitymys* burrows in flower beds where the animals were doing considerable damage to lily bulbs. In Horse Cove one was taken from well-marked burrows underneath a haystack.

Specimens.—Nine, seven preserved; localities 5, 9, 11, 13.

Measurements.—Av., 3 adult males: 122, 20, 19; wt., 22.3 grams. Two adult females: 125, 25, 17; wt., 28.9 grams.

Ondatra zibethica zibethica (Linnaeus). Muskrat.—Occurs on small artificial lakes of the region, although its activities are very little in evidence during the summer. Definite records include a complete skeleton found on the bank of Lake Ravenal in early June, 1947. Trappers are said to take a few in the region.

Rattus rattus alexandrinus (Geoffroy). Roof rat.—Chamberlain trapped a sub-adult female of this species near a stream, on Route 64 about one mile east of Highlands, on June 20, 1930. The specimen is now in the Charleston Museum. A second specimen collected October 13, 1932, by T. D. Burleigh at Highlands is in the National Museum.

Zapus hudsonius hudsonius (Zimmermann). Meadow jumping mouse.—Definitely occurs in the fields and bushy ditches along the highway between Burnette's store and Scaly. In June, 1947, Mr. Burnette saw one hop across the road, and on July 20 he succeeded in catching one alive in a field nearby. The specimen was kept for the rest of the summer in the Museum and was eventually preserved as a skin by Dr. J. J. Friauf.

Measurements.—Female: 196, 123, 28; wt., 15.0 grams.

Reproduction.—On July 31, eleven days after capture, four young were born, but they did not survive in captivity.

Napaeozapus insignis roanensis (Preble). Woodland jumping mouse.—This beautiful and elusive mouse of the north woods has been recorded twice from Highlands, once by Howell in 1930 ("Primeval Forest") and once by ourselves. We also took a third specimen in Rabun County, Georgia, just over the North Carolina line at an altitude of 3075 feet, which is the first record for this species from Georgia. Both of our specimens were taken near small streams in wooded ravines.

Specimens.—Two; locality 5, and Rabun Co., Ga.

Measurements.—One male: 235, 149, 34; wt., 20.4 grams. One pregnant female: 220, 135, 29; wt., 23.8 grams.

Reproduction.—Female, taken June 21, 1948, contained four large embryos, near term.

Sylvilagus floridanus mallurus (Thomas). Cottontail.—Common, especially in the cut-over bushy areas and on cultivated lands.

Specimens.—Two; localities 1 and 7.

Sylvilagus transitionalis (Bangs). New England cottontail.—Occurs at Highlands, but exact status and abundance relative to that of *floridanus* has not been determined. It apparently is common in the forested regions at high altitudes, since a number of small rabbits seen in forests are believed to have been of this species. Our only positive record is a young specimen rescued from an attacking chipmunk (see details under chipmunk) just outside the laboratory window.

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Department of Biology, University of Georgia, Athens, Ga. *Received August 7, 1948.*

GENERAL NOTES

OBSERVATIONS ON THE NORTHERN ELEPHANT SEAL, *MIROUNGA ANGUSTIROSTRIS*

Incidental to a sardine research trip in March and April of 1948, made by the California Division on Fish and Game research vessel "N. B. Scofield," numerous northern elephant seals (*Mirounga angustirostris* Gill) were observed at Guadalupe Island, and also at Middle and West San Benito islands, Lower California, Mexico.

Guadalupe was circumnavigated to obtain a reasonably accurate count of the elephant seals present at the various beaches and coves. Two main groups were hauled out; one at the sandy cove just south of Pilot Rock, on the east side of the island, and another at Elephant Beach, south of Elephant Rock on the west side of the island. An attempt was made to count each individual on these two beaches, but due to large numbers and movement only an approximation could be reached. The counts and estimates of elephant seals made March 31–April 1 are indicated by locality in Figure 1. Total estimate was 2891.

At West San Benito Island approximately 700 elephant seals were indicated by shore counts, along with numerous California sea lions. Elephant seals were also seen with field glasses on Middle San Benito Island, but no shore count was made. Williams (Nat. Hist., 48 (3):144–49, 1941) observed elephant seals at several coves of East San Benito Island, which were not visited on this trip.

No elephant seals were observed at either Cerros Island or along the Lower California mainland, but since a thorough search was not made in these areas, it cannot be assumed that they were not present.

In order to determine whether or not the elephant seals left the beach at night to feed, the "Scofield's" searchlight was turned on the large herd at the northest end of Guadalupe. No apparent reduction from daytime numbers was observed. The group displayed extreme agitation, moving about rapidly in an aimless manner to escape from the searchlight's beam, contrary to the behavior when approached by man during the day.

On the same beach several individuals had been crushed by massive boulders falling from the cliffs above. This did not cause abandonment of the area where the landslide occurred.

Townsend (Zoologica, 1 (8): 159–73, 1912) gives the original range of the northern elephant seal as extending from Cape San Lazaro, near Magdalena Bay, Lower California, northward to Point Reyes, near San Francisco, a distance of nearly a thousand miles. For

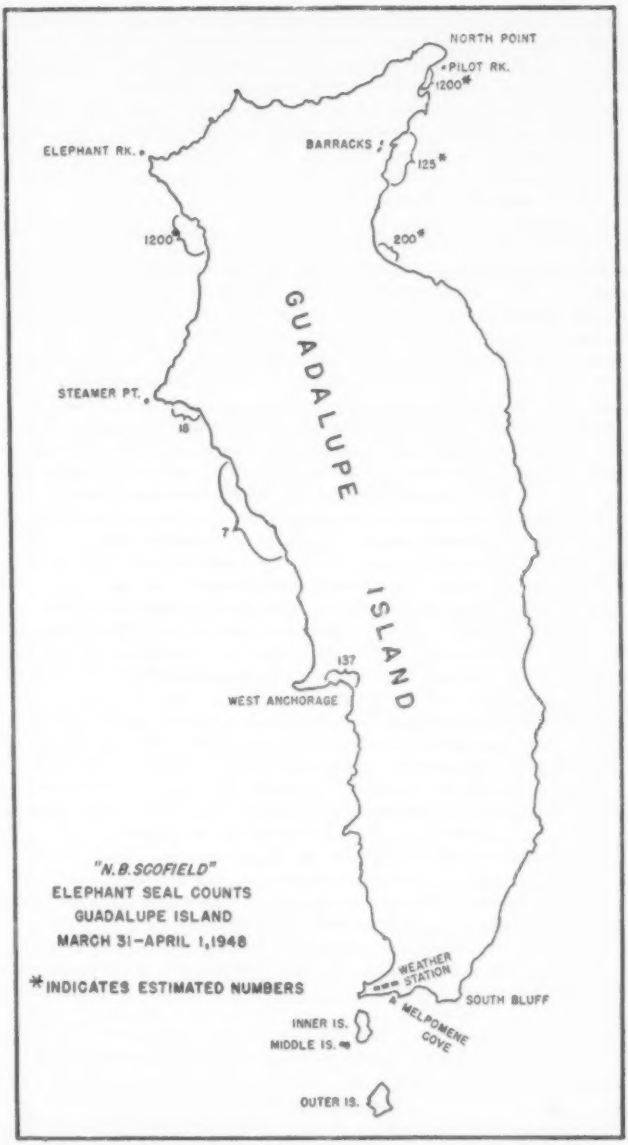

FIG. 1.—Distribution of elephant seals on Guadalupe Island

many years, due to the depredations of man, the herds were limited to a few small groups on islands off the coast of Lower California. Only an occasional straggler reached the vicinity of the Channel Islands off Southern California. A group of twenty-one individuals was

counted, hauled up on one of the Channel Islands, during a sea lion census conducted by the California Division of Fish and Game in 1946, so it appears that they may be reestablishing themselves there. Since 1922, Guadalupe Island and its territorial waters has been "reserved for the protection and development of the natural resources . . . ." Since then the herds of elephant seals have increased from near extinction to the point where apparently some individuals are migrating from Guadalupe to other islands which they formerly inhabited. For previous counts see Anthony (Jour. Mamm., 5: 145–52, 1924) and Huey (*Ibid.*, pp. 237–42).—JOHN E. FITCH AND ROBERT C. WILSON, *Bureau of Marine Fisheries, Calif. Div. of Fish and Game. Received July 17, 1948.*

BREEDING OF THE PHILIPPINE TREE SHREW, *UROGALE EVERETTI* THOMAS

The Chicago Zoological Park at Brookfield, Illinois, received on July 30, 1947, a pair of Philippine tree shrews, *Urogale everetti* Thomas. These attractive little animals with their dark brown fur, rufous underparts, pointed noses, and strangely human-like ears were the first of the Tupaiidae to be shown in the Park. We assumed them to be young individuals just maturing as within a month a light-colored, chevron-like marking appeared on the shoulders of both. It was not until we had had them for some days that we knew them to be definitely a male and female. Separate cages were used for some weeks and then, after they had become acquainted through the screen, they were put together for a short time. No fighting or sexual activity was noted, but there was considerable friendly racing about the cages, some mutual grooming, and much play. Three days later when put together, two matings occurred within ten minutes, and at least six more took place before the animals were separated when the house was open to the public. Similar sexual activity was seen on the several following days until one morning the female, while willing to play, abruptly rejected the advances of the male; when he persisted, acrimoniously (they have a wide range of vocalization), she chased him into his own compartment very much on the defensive.

About this time they were moved to a new cage, glass fronted, 5 x 2 feet x 3 feet high with a slide to divide it in half. A nest box about a foot square with a round opening into the cage is attached to the female's side. A hinged top permits a look into the nest box. In this large double cage, with its many branches for climbing, the shrews with their almost incessant activity make an excellent show. They quickly became fairly tame. Although the male has a tendency to nip fingers, it is seemingly not from malice, but from curiosity. The male is less wary of people than is the female, but it is obvious that she is the dominant member of the family, and that his status is definitely that of a hen-pecked husband. When an attempt to feed them together was made, the male was immediately chased to the topmost branches where he stayed while his good lady, chattering quarrelsomely, ate what she wanted and scattered the rest of the food about the cage floor. Their food habits, incidentally, are such as to endear them to any animal keeper. Meat, insects, fruits and vegetables of all sorts, and eggs are eaten with gusto. As a special treat, infertile bird and turtle eggs are given when available, and are opened with a skill and lack of waste which indicates considerable experience with such food in the wild.

After being put in their new home, shrew life seemed to settle down to a pattern of periodic sexual activity and quiescence, but it was difficult to determine any definite period for these. The female underwent several partial moults with new hair promptly replacing the old.

We had had the pair for nine months when, in the early afternoon of May 3, the female—she had been kept apart from the male for some days because of her bigness and our hopes and suspicions—was seen to drag a pinkish object out of the nest box and immediately return with it. She was decoyed away with food and a stillborn male baby was found on top of the bedding material of the box. It was without obvious mark or blemish. The cord had been severed about an inch from the navel and was beginning to dry. Claws were well developed on all digits; the eyes were closed and hairs about a quarter of an inch or more long were scattered over the otherwise naked skin. The length of the baby from tip of tail to end of snout was 101 mm. of which the tail was 35 mm.

They were put together again and copulations were observed on the fourth day after the birth. These continued from time to time for a number of weeks. Fifty-four days after the birth of the first baby, a second was born. For some days the female had been quarrelsome with the male and, contrary to their usual habit of playing in and out of the nest box, would not allow him to come near the nest. She looked big, but it was because of her odd behavior that we assumed that she was going to have young and prepared for it. The nest box was thoroughly cleaned—it had a strong ammonia smell and there was considerable excrement, peanut hulls, and the like in the bottom—and clean excelsior and cut paper was put in it. The male was not allowed in the compartment. The female spent the morning fussing with the nest material and, in the afternoon at feeding time, although usually eager for food and anxiously waiting for it, was reluctant to leave the nest. When she did go to her food, a quick look in the box revealed a living baby just the same size, apparently, as the stillborn.

On the days following, the box was not disturbed except for a quick check while the mother ate. On one occasion, the infant was on top of the nest material, but at other times was bedded in a neat little hollow. When the box was opened and the bedding moved so the baby could be seen with the aid of a flashlight, it responded by making a half-snuffling, half-crying noise until twelve days old and then abruptly stopped. After that, a little squirming when the bedding was lifted back was the only indication that it was disturbed. About this time, a favorable view showed us that we had another male.

The mother, although previously in and out of the nest a hundred times a day and accustomed to take her rest in the entrance, avoided it carefully and was not seen to enter the nest box until two weeks had elapsed. Her visit was short. It was not until the fourth week that she began to go into the box twice daily, once in the morning and once in the late afternoon, and remain for about ten minutes. On coming out, grooming of the belly indicated she had been nursing. Mammae were not visible, but a check of a preserved specimen in the collection of the Chicago Natural History Museum showed four. They were difficult to locate and were in the positions described by Lyon (Proc. U. S. Nat. Mus., 45: 1-188, 1913) as postaxillary and lateral.

Hair on the baby grew fast and by the time the eyes were open on the nineteenth day, the body was completely covered with fur of the same color as the parents and, curiously enough, the shoulder stripe was plainly evident. When, in the middle of the fifth week, the baby emerged from the nest box which the mother had kept sweet and clean, it was able to climb about the cage with almost as much agility as its parents, and promptly began to share its mother's meals. Its weight when six weeks old was 123 grams. At seven weeks, weight had increased to 145 grams. The weight of the male at this time was 355 grams.

Other than a sign, "Please do not tap on the glass," above the cage—the guard rail is only twenty-two inches from the cage front—no special effort has been made to protect these animals from our large crowds of visitors, and the youngster has been reared in an atmosphere of continual racket and confusion when the house is open to the public. The youngster, like his parents, is without fear of people, and, in addition, can be handled. Our only hazard with our shrews is the inordinate curiosity of the two males particularly which impels them to try to scramble with incredible speed up an arm and out to wider horizons when the cage is opened and opportunity offers.—ROBERT SNEDIGAR, *The Chicago Zoological Park, Brookfield, Illinois.* *Received August 30, 1948.*

DEATH FROM FRIGHT IN LONG-TAILED SHREWS

H. H. T. Jackson (N. Amer. Fauna, no 51, 1928) and others have recorded the sudden death of long-tailed shrews of the genus *Sorex*, due seemingly to sudden shock or fright. Two similar observations of this sort made recently by the writer seem worth recording.

At about 8:00 A. M. on the morning of October 26, 1947, while I was sitting in a duck blind 1½ miles SW of Suisun, Solano County, California, a shrew (*Sorex sinuosus*) was seen moving actively over some dead cattail stalks nearby. After capturing the animal by gently closing my hand over it I placed it in an empty shell box. For a few minutes it could

be heard moving about in an attempt to escape, then it was forgotten for a while. During the ensuing hour shotguns were fired repeatedly, near and far. When I looked in the box shortly after 9:00 A. M. the shrew was dead.

In the summer of 1948 I had another experience, with a shrew, that was similar to an account described by Jackson (*supra cit.*, p. 8). At 11:00 A. M. on July 9, in the northwestern part of the Bitterroot Mountains, 6 miles SSW of Lolo Pass, Idaho County, Idaho, a gray shrew (*Sorex cinereus cinereus*) was seen running about in a dirt road in front of the car I was driving. I stopped the car, jumped out and, after noting that the shrew seemed to be searching for food, placed my cap over it. To my amazement, when I removed the animal from beneath a moment later it was found to be dead.

In the two afore-mentioned incidents neither of the shrews was injured during capture. Furthermore, a careful examination of the body of each animal as it was being prepared as a specimen, failed to disclose any signs of previous injuries. To all appearances these deaths had resulted from fright or sudden shock.—ROBERT T. ORR, *California Academy of Sciences, San Francisco, California. Received October 25, 1948.*

AQUATIC ACTIVITY OF A DESERT KIT FOX

On August 29, 1948, the writer and two friends were fishing in the Coachella Irrigation Canal, about five miles north of its origin on the All-American Canal, approximately twenty-eight miles west of Holtville, Imperial County, California. At this point, there is a check dam with a seventy-foot, forty-degree spillway. Below the spillway, a concrete apron extends downstream about one hundred yards to prevent the swift water from destroying the canal banks. The sides of this apron are on an angle about forty degrees from the horizontal. Three hundred twenty-five second-feet of water were flowing through the canal, which at this point had a width of about forty feet.

We were fishing just below the spillway on the west side of the canal, at 1:30 P. M., when a desert kit fox, *Vulpes macrotis arsipus*, approached the canal on the opposite side and about twenty-five yards downstream. The wind was in our favor, and the animal seemingly was unaware of our presence. The gait of the fox was normal, and no fright was apparent in his actions. He stopped at the edge of the concrete apron leading to the water and looked carefully around him. Then, slowly, he made his way down the concrete embankment to the water's edge, stopping with both forepaws very slightly in the water. After thus remaining for perhaps half a minute, he walked into the water belly-deep and struck out, dog-like, attempting to swim across the current. We were at such a distance that the movements of the feet were not clear; the tail was not visible above water. The nose and top of the head were above the surface, similar to a swimming dog in this manner. The current here was very swift and the fox was being quickly swept downstream despite his efforts to maintain his position. He was about six feet out from the bank, where the depth of water was about three feet, when he abruptly turned downstream, swam a short distance, then made back for the bank. Gaining a foothold on the cement, he walked on up the apron, dripping wet; the tail drooped, almost dragged. At the top, the animal paused and, without looking back, gave a few convulsive shrugs which ineffectually eliminated part of the water from the fur. This was more of a front-to-rear movement than the seemingly more natural and efficient, violent, shaking of a wet dog. With the same unconcern exhibited throughout the whole event, the fox slowly trotted off in the direction from which he had come.

At no time did the animal seem aware of our presence. The action was completed just as if it had been the normal course of events. The fox showed no alarm, even when the current pulled him swiftly downstream. It is not possible to say whether the kit fox normally enters the water, if it is available. However, the unconcerned activity of this individual seems to indicate that aquatic ventures are somewhat less rare in these animals than is ordinarily believed.—WILLIAM G. REEDER, *Dept. of Zoology, Univ. of Calif., Los Angeles 24, California. Received October 11, 1948.*

TIMBER WOLVES (*CANIS LUPUS LYCAON*) KILLED BY CARS ON ONTARIO HIGHWAYS

When checking records of wolves turned in for bounty, it was amazing that so many of them were reported to have been killed by cars on highways last winter (1947–48). As far as I can determine, such road kills were quite rare in the past, even as late as two and three years ago. From March 1, 1947, to March 1, 1948, not less than fourteen timber wolves and seven coyotes were run down by cars, and turned in for bounty claims in Northern Ontario. In three northwestern forest districts where highways are present, the highway kills for timber wolves were: Kenora, 3; Thunder Bay, 4; Geraldton, 5.

It was possible for me to get additional information about three of these timber wolves which were run down in the Thunder Bay District. On December 1, 1947, one female was killed at night, about thirteen miles north of Neys, by a truck. She was running along the road in a pack of eight wolves. On December 16, 1947, one female was killed on Highway 17, ten miles east of Nipigon. This wolf, about two years of age, was autopsied by me. Although no fat deposits were present, it appeared to be in good physical condition. The stomach was half-filled. On January 25, 1948, a male was killed at 10:00 P. M. on Highway 17, five miles west of Upsala. Autopsy showed that it was an adult in excellent physical condition, with fat deposits on the breast and on the abdomen. Endoparasites belonging to the genera *Taenia* and *Diphyllobothrium* were found in the viscera.

It is difficult to suggest why so many wolves have been killed lately on the highways. I do not believe that an increase in the speed of travel of cars and an increase in the numbers of cars on the northern highways are the only reasons for it. Although the timber wolf population is somewhat higher than normal, according to wolf bounty statistics, it does not appear to be abnormally high. It is interesting that the consensus of old timers in Northern Ontario is that wolves were never seen as frequently in settled areas in early years as they are now. During the last four or five years, more timber wolves have been seen in farm areas than ever before. It is possible that this may indicate a change in the behaviour of these animals. It may also be a result of an increased population pressure. If the latter is the case, we may expect signs of epizootic diseases in the near future.—A. DE VOS, *Department of Lands and Forests, Port Arthur, Ontario. Received October 13, 1948.*

HUNTING HABITS OF THE BAT, *MYOTIS EVOTIS*

Early in September, 1948, several bats with relatively long ears were seen early each evening as they hunted in the open spaces in the red fir–lodgepole pine forest (elev. 7500 ft.) near Huntington Lake, California. The bats flew slowly in nearly straight courses as they caught their insect food about forty feet above the ground. Presumably the same bats were regularly seen catching insects later in the evenings about outdoor camp fires and within the lighted space about an outdoor electric lamp. They could not be collected by shooting because the area was within a game preserve. Just how to obtain some of the animals for identification became a problem until it was recalled that there was a tunnel dug for water some 200 yards farther up the side of the mountain, which was thought possibly to be the daytime retreat of the animals. The next day before dusk a mosquito net was spread across the mouth of the tunnel with the hope of catching any bats that attempted to leave the entrance. At 7:30 P. M. (daylight saving time) the first bat appeared overhead and in a few minutes ten were counted coursing the open space in the forest along the mountain side. None of the bats had come from the tunnel and after an hour's wait the attempt to obtain specimens in the mosquito netting was considered a failure. It was noticed, however, that as it became darker and as the air became colder the bats hunted nearer the ground. Then, almost simultaneously, two bats tried to enter the blocked tunnel. A corner of the cloth was then folded down and immediately a bat entered the opening, but it was captured only after it had leisurely flown about several minutes feeding on insects that were still actively flying about in the warmer air inside the tunnel. During the next hour no other bats were seen.

The next evening a watch was again maintained and the first bat appeared overhead at precisely 7:29 P. M., soon to be followed by several others all of which were hunting well above the ground. It was about an hour later before any bats attempted to enter the tunnel and, at that time as on the previous night, the temperature of the air had fallen sharply as a result of the down-mountain air currents. Another bat was captured, but no more attempted to enter after another hour's watch.

Nearly all observers describe *Myotis evotis* as a "late evening" bat. Such, however, was not the case here at this time of year where they were regularly seen in numbers early each evening. These observations seem to be the first record of this species well within the Canadian Life Zone, within California. They also indicate that the best hunting time for this bat is the hour following dusk just before the rapidly lowering temperature stills the insect species in the upper strata of the forest. The first hour following dusk culicid species and other aquatic insects become relatively inactive at these altitudes at this time of year except where the air is kept warm, as in tunnels, about camp fires, and about outside electric lamps. In such places *Myotis evotis* may extend considerably its otherwise short nightly hunting period which it starts higher up in the forest.

The species identification was verified and because the specimens were near a Cinnamon Buff in color they were presumed to belong to the subspecies *chrysonotus*. They were sent alive to Mr. Ernest P. Walker of the National Zoo for experimental purposes.—Lloyd G. Ingles, *Fresno State College, Fresno, California.* *Received September 27, 1948.*

THE PIPISTREL (*PIPISTRELLUS SUBFLAVUS*) IN NORTHERN WISCONSIN

There are few published records for the pipistrel bat, *Pipistrellus subflavus* (F. Cuvier), in the northwestern portion of its range. To our knowledge there are no published records for Iowa or Michigan and only a few for Wisconsin and Minnesota. The most northern of these records are for Sauk County, Wisconsin (Jackson, Jour. Mamm., 1:38, 1919) and Washington, Goodhue, Wabash, and Nicollet counties in Minnesota (Swanson, *et al.*, Mammals of Minnesota, p. 60, 1945). There are several other records for southwestern Wisconsin.

A single specimen of *Pipistrellus subflavus* was taken from more than 3200 *Myotis lucifugus* and *Myotis keenii* which were trapped for banding on September 1, 2, and 3, 1948, at Hurley, Iron County, Wisconsin. This pipistrel, number 479 in the collection of James Beer, was a fat male apparently ready for hibernation. This same place was trapped during September of 1947 when nearly 1400 bats were examined without finding a single individual of this species.

Our trap was located about fifty feet underground and about 150 feet from the entrance of a cave-in in an old abandoned iron mine. It was set to intercept and trap most of the bats that used this entrance to leave the extensive deeper workings of the mine at dusk. This mine is known to have hibernating bats throughout the winter and there are apparently a few pipistrels among them.

This extends the known range of *Pipistrellus subflavus* to within a few miles of the southwestern shore of Lake Superior and to within less than two miles of the border of the Upper Penninsula of Michigan.—Frederick Greeley and James R. Beer, *University of Wisconsin, Madison, Wisconsin.* *Received September 25, 1948.*

MEXICAN RECORDS OF THE BAT, *CENTURIO SENEX*

The type of *Centurio senex* Gray (Ann. Mag. Nat. Hist., 1842, ser. 1, vol. 10, p. 259) was thought at first to have come from "Amboyna," but it must have been taken in Central America or possibly on the west coast of Mexico.

Saussure, in 1860 (Rev. Mag. Zool., ser. 2, vol. 12, pp. 381–383), described *C. mexicanus* from "les regions chaudes du Mexique," and the following year Harrison Allen (Proc. Acad. Nat. Sci. Philadelphia, 1861, pp. 360–361) described another species, *C. mcmurtrii*, from Mirador, Vera Cruz, Mexico. This bat received still another name when Ward (Amer. Nat., 1891, vol. 25, pp. 750–753) named a fourth species, *C. minor*, from Cerro de Los Pajeros, Las Vegas, Vera Cruz, Mexico. These were all synonymized with *senex* by Rehn (Proc. Acad. Nat. Sci. Philadelphia, 1901, p. 297).

Mr. Melvin Traylor of the Mexican Zoological Expedition, 1948, Chicago Natural History Museum, brought back one specimen of *C. senex* from Dos Caminos, km. 354, Vera Cruz, 4500 feet altitude. It was shot by his Mexican assistant who saw it hanging alone in a tree. This is the first time the habitat of this bat has been noticed. The 36 specimens brought to Schmidt (Sanborn, Field Mus. Nat. Hist., 1936, Zool. Ser., Vol. 20, p. 104) were received on six days, from two to twelve specimens each day, but the Indians would not tell where they were found.—COLIN CAMPBELL SANBORN, *Chicago Natural History Museum, Chicago 5, Illinois. Received October 14, 1948.*

MOUNTAIN LION IN SOUTHEASTERN TEXAS

The mountain lion (*Felis concolor*) was probably found throughout Texas prior to settlement by the white man. Today this animal occurs only in small numbers and is confined principally to the areas bordering the Republic of Mexico and to the western mountainous country. Mr. C. R. Landon of the U. S. Fish and Wildlife Service (*in litt.*, 5 August 1948) writes me that "There is no doubt in our minds that mountain lions breed in the Texas brush country in Webb, Duval, and other counties toward the Rio Grande Valley." Occasionally lions are taken or are reported in central Texas. Whether they remain in this locality and become established as breeding residents is uncertain.

As far as I can learn there have been no records of the taking of mountain lion in southeastern Texas in recent years. There are occasional reports; Mr. Landon (*loc. cit.*) has obtained reports of the mountain lion in Jackson, Wharton, and Brazoria counties. The taking of a specimen in Colorado County in 1948 is therefore considered to be worthy of note. The animal, an adult male, was treed by dogs and shot by Mr. Emil Balusek of Rock Island in the Phoenix Dairy Pasture, 15 miles south of Rock Island, Colorado County, Texas, on 26 February 1948. This locality is approximately 72 miles WSW of Houston. The mountain lion was described as being "very fat" and weighing approximately "120 pounds." The skin has been tanned and mounted and is in the possession of the collector. With the aid of State Game Warden T. T. Waddell of Eagle Lake, Texas, I was able to obtain the skull, which is now No. 24880 in the Museum of Natural History, University of Kansas. Residents in Colorado County have remarked to me that in their lifetimes they have never heard of another such animal in the county. Probably this mountain lion reached Colorado County from the Rio Grande Valley area by way of the brush country bordering the Gulf coast. A comparison of this skull with descriptions and figures in Goldman (Young and Goldman, "The puma, mysterious American cat," 1945, p. 232, pls. 49, 58, 67, 76, 82, 88, 93, fig. 6) shows that it is referable to *Felis concolor stanleyana* Goldman. —ROLLIN H. BAKER, *Museum of Natural History, University of Kansas, Lawrence, Kansas. Received September 30, 1948.*

NEW LOCALITY RECORDS FOR THE DEER MOUSE, *PEROMYSCUS M. PALLESCENS* (ALLEN)

Five juvenile *Peromyscus maniculatus pallescens* (Allen) were trapped in April, 1948, on the John Tyler farm, two miles south of Taylor, Williamson County, Texas. Another was taken at the same place on August 1, 1948. On May 4, 1948, J. L. Reagan and I caught a single adult female three miles northeast of Bertram, Burnet County, Texas. This subspecies is generally considered rare. Osgood (N. Amer. Fauna no. 28: 83, 1909) listed only 14 specimens from four localities, all in Texas: Alice, 1; Gainesville, 1; San Antonio, 11; Waco, 1. Subsequent specimens have possibly been collected, but, so far as I know, no other records have been published.

The six Taylor specimens (4 males and 2 females) were taken in live traps set along a shallow grass-covered ditch at the edge of a cotton field. The grasses were principally Johnson, blue-stem and Bermuda (*Sorghum halepense*, *Andropogon saccharoides*, and *Cynodon dactylon*). Traps set near a large patch of Georgia cane (*Arundo donax*) were not sprung. A number of small holes (1½ inches in diameter) were found in the grass areas, and three of the six specimens were taken in traps set close to these holes. The other three were caught close to small piles of cotton stalks which had been raked onto the grass. The

first five animals are being kept alive for use in breeding experiments in progress under the direction of Dr. W. F. Blair. The August 1 specimen is now in the University of Texas Natural History Collection, number T901; the measurements are: total length, 122 mm.; tail length, 46 mm.; right hind foot, 18 mm.; ear from notch, 12 mm.

The Bertram specimen was found under a large (30 inches in diameter) flat rock lying at the roadside bordering a rocky grass-covered field. Under the rock was a series of runways having openings at opposite edges of the rock and leading to a tunnel near its edge. The tunnel was about one and one-half inches in diameter with an inclination of 30 degrees. About fifteen inches from the entrance, the tunnel leveled off and branched to a spherical side room four inches in diameter. Fifteen inches farther along the tunnel we found nesting material of dry shredded grass, but the tunnel was lost. This specimen is now in the University of Texas Natural History Collection, number T27; the measurements are: total length, 128 mm.; tail length, 54 mm.; right hind foot, 18 mm.; ear from notch, 14 mm.

Further attempts are in progress to trap a breeding stock of this subspecies; and it may prove to be quite common in Taylor, where much sign was found.—Alvin Flury, *Department of Zoology, University of Texas, Austin, Texas. Received August 21, 1948.*

NEOTOMA FLORIDANA HAEMATOREIA HOWELL (WOOD RAT) IN SOUTH CAROLINA

I wish to record the capture of three specimens of *Neotoma floridana haematoreia* Howell in South Carolina. The first specimen, an immature female, No. 1685 in my collection, was taken on 22 November, 1941, about a mile and a quarter from Caesar's Head Hotel, Geer Highway, Greenville County, South Carolina, at an elevation of approximately 3000 feet, among granite rocks blasted out of the mountain side in the construction of the highway along a precipitous ledge. The second specimen, an immature male, No. 1697 in my collection, was taken the following night in exactly the same spot. The third, a subadult male, No. 1965 in my collection, was taken among the same rocks five years later on 28 November, 1946.

So far as I have been able to learn these three specimens constitute the first and sole record of the subspecies for South Carolina.—Robert H. Coleman, *Route 8, Box 615, Charleston, S. C. Received August 4, 1948.*

WOODLAND JUMPING MOUSE (*NAPAEOZAPUS*) IN GEORGIA

On June 21, 1948, we trapped a female *Napaeozapus insignis roanensis* near a small stream in a wooded ravine in Rabun County, Georgia, near the North Carolina Line, at an elevation of 3075 feet. This appears to be the first actual record of this species in Georgia, although we feel certain that further work will demonstrate that the woodland jumping mouse occurs, at least locally, throughout the mountainous portion of the state. The uterus of our specimen contained four embryos near term. The skin, skull, and embryos are preserved in the University of Georgia collection.

Two specimens of *Napaeozapus* have been taken in the vicinity of Highlands, North Carolina about eleven miles north-east of the Rabun County locality, one by us on June 10, 1948, and one by Arthur H. Howell in 1930.—H. V. Autrey and Eugene P. Odum, *University of Georgia, Athens. Received August 7, 1948.*

FIRST RECORDS OF PORCUPINE ON THE MOHAVE DESERT OF CALIFORNIA

In May, 1947, while doing some zoological field work near the far eastern end of the Mohave River, Mr. Lee Smith of the Camp Cady Ranch showed me a small vial of fresh porcupine quills which he had recently plucked from the face of one of the ranch dogs. The animal evidently had had an encounter with the porcupine while out prowling around during the night among the numerous mesquite, cottonwood, willow, and cats claw trees which grow in the wide bottoms along the river. I believe this is the first record of porcupine being found on the low Mohave Desert. It is interesting to note its presence here in connection with Mr. Gale Monson's record of this animal, (Jour. Mamm., vol. 29, p. 182,

1948) in the dry isolated Kofa Mountains in the deserts of Arizona some 160 miles southeastward, also in the cottonwood-willow woodland of the Big Williams Delta.

In April, 1936, I found evidence of porcupine (5700 ft. alt.) in the higher parts of the New York Mountains located in the desert in Eastern San Bernardino County, California. Numerous places could be seen where these animals had eaten away the bark of the single leaf pinon (*Pinus monophylla*) during the preceding winter. The nature of the tooth marks gave indisputable proof of the identity of the rodent concerned. The presence of porcupines in the New York Mountains is not unduly surprising since these highlands are more or less of a southern continuation of fairly high, wooded country found in southern Nevada. There, Burt (Trans. San Diego Soc. Nat. Hist., 7:422, 1934) records the presence of *Erethizon epixanthum couesi* in the Charlston (Spring) Mountains and Sheep Mountains, Clark County. The occurrence of this rodent in such an isolated spot in the dry mid-desert as at Camp Cady is more difficult to explain.—Edmund C. Jaeger, *Riverside College, Riverside, California. Received September 30, 1948.*

WAPITI IN DELAWARE

There appear to be no records, in zoological literature, of wapiti (*Cervus canadensis*) in the State of Delaware, although nearby points in Pennsylvania are mentioned (Rhoads, Mammals of Pennsylvania and New Jersey, p. 241, 1903, and Bailey, Jour. Mamm., vol. 18: 104, 1937). The following record thus has some small interest.

A calcaneum, identical in size and form with that from a modern wapiti, was recovered by Alfred G. Schroeder in 1948 from an excavation for a basement at a site beside White Clay Creek, about one-half mile off Harmony Road, seven miles northeast of Newark, Delaware. This bone lay in the earth at a depth of about six feet. In the same excavation, but at a lesser depth, was a well-weathered shell which W. J. Clench of the Museum of Comparative Zoology has identified as *Turritella variegata* Linné. This species today is recorded only from Texas and the West Indies. The Delaware specimen agrees perfectly with specimens from Puerto Rico. The species may possibly have existed along our southeast coast during some post-Pleistocene warm period and since died out. If so, the *Cervus* would be a Pleistocene record. Both the *Cervus* and the *Turritella* have been deposited in the United States National Museum.—R. T. Hatt, *Cranbrook Institute of Science, Bloomfield Hills, Michigan. Received September 24, 1948.*

EXTENSIONS OF THE KNOWN RANGES OF THREE SPECIES OF TEXAS MAMMALS

Specimens in the Texas Natural History Collection extend the known ranges of three species of mammals. An adult male and female *Dipodomys elator* Merriam were collected by D. G. Walker and myself on June 24, 1947. These kangaroo rats were taken about fifteen miles south of Vernon, Wilbarger County, Texas. These records extend the known range of this little-known species westward about seventy-five miles from Henrietta, Clay County, Texas. This species is known also from Chattanooga, Oklahoma (Bailey, N. Amer. Fauna, 25: 149, 1905). The range of this kangaroo rat, as now known, comprises a roughly triangular area about seventy-five miles by fifty miles by fifty miles. The two animals were found living in sections of pipe in a mesquite–grama grass association. This species appears to have a restricted range in the northeastern part of the rolling mesquite–grama grass plains of northern Texas. Intensive collecting in the summers of 1947 and 1948 failed to take this form in the mesquite–grama grass association of Throckmorton County, about seventy miles south of the Wilbarger County station, or in a similar association in Cottle County, a like distance west of Wilbarger County.

Four specimens of the spiny pocket mouse (*Liomys irroratus texensis* Merriam) were collected on December 23 and 24, 1947, about ten miles northwest of Raymondville, Willacy County, Texas. These records extend the known range of this species in Texas northward about forty miles from the Río Grande. Previous records from the state were from the lower Río Grande Valley and in close proximity to that river. These specimens were

trapped in a mesquite-cactus-grass association that is distributed widely over the Río Grande Plain of southern Texas. It seems likely, therefore, that this species will be found to extend even farther north than the present records indicate.

A skin of the ringtail (*Bassariscus astutus flavus* Rhoads) from Jefferson County, Texas, was obtained for the Texas Natural History Collection by D. G. Walker. This animal was shot about seven miles east of Beaumont by a commercial fur trapper who found it crossing a road at night in December, 1947. The ringtail is common on the Edward's Plateau of central Texas. Bailey (N. Amer. Fauna, 25: 182, 1905) reported the species as far east in Texas as Matagorda County on the coast. Taylor and Davis (Tex. Game, Fish and Oyster Comm., 27: 24, 1947) stated that, "it is common east to the Trinity River, but rare east of that stream." The present record is the most eastern one of which I know, and it indicates that the species ranges across the Neches River nearly to the Louisiana line in southeastern Texas.—W. Frank Blair, *Department of Zoology, University of Texas, Austin 12, Texas. Received October 13, 1948.*

A RECENT RECORD OF AN ALBINO TEXAS JACK RABBIT

The index to the Journal of Mammalogy (Vols. 1–20 inc., 1919–1939) reveals that no article had appeared on albino jack rabbits, *Lepus californicus texianus*, in that publication during the period.

On August 4, 1947, Mr. Fred N. Ares, employee of the Forest Service, and stationed at the Jornada Experimental Range, New Mexico, killed a white rabbit in Dona Ana County, New Mexico. The approximate location is the south-east corner of section 16, township 19 S, range 1 E. The specimen was preserved by me and submitted to Dr. H. H. T. Jackson, in charge, Biological Surveys, at the National Museum, in Washington, D. C., and was identified as an albino Texas jack rabbit, *Lepus californicus texianus*.—Cecil A. Kennedy, *Fish and Wildlife Service, Las Cruces, New Mexico. Received September 27, 1948.*

SYPHACIA THOMPSONI (NEMATODA: OXYURIDAE) FROM THE RED SQUIRREL

The caecum of a female red squirrel, *Tamiasciurus hudsonicus* Erxleben, collected at Phelps, Vilas Co., Wisconsin, January 3, 1948, was found to contain thirty-two small oxyurid worms which proved to be *Syphacia thompsoni* Price. We were especially interested to note that all of these nematodes were males. This finding constitutes a new host record, as the previously known North American hosts of this species are the southern flying squirrel, in Virginia, and the northern flying squirrel, in northern Michigan and central Wisconsin. To date we have data on fifty-nine red squirrels, and only the above-mentioned animal was found to be infected with *S. thompsoni*. However, some of the red squirrels were collected in southern Michigan and Ohio where *Enterobius sciuri* would appear to replace *Syphacia thompsoni* as a parasite of *Glaucomys* (see Rausch and Tiner, Amer. Mid. Nat., 39: 728-747, 1948).

Male oxyurids are characteristically smaller than the females, and they apparently do not live long after the latter have been fertilized. It is not unusual to find that all males of a given generation have disappeared by the time the females have become distended with eggs. Consequently, we do not think it likely that any of the latter would have been overlooked, especially since care was taken to collect all worms present. It would seem most probable that, in this instance, the sex ratio encountered can be explained by the occurrence in an unnatural host. Should the ordinary sex ratio for very young *S. thompsoni* be 1:1, then the probability of the occurrence of thirty-two male worms in the complete absence of females would be one in 4,294,967,296.

It appears quite possible that the infection was acquired at a single exposure, or within a relatively short interval, since all the worms were of uniform size. Several were measured and averaged almost 3.0 mm. long. *Syphacia thompsoni* was originally described as being 3.1 mm. long (Price, Proc. U. S. Nat. Mus., vol. 74, Art. 4: 1–4, 1928).—Jack D. Tiner and Robert Rausch, *Vivarium Building, University of Illinois, Champaign, Illinois, and*

Department of Veterinary Science, University of Wisconsin, Madison 6, Wisconsin. *Received September 24, 1948.*

OCCURRENCE OF RABIES IN DEER (*ODOCOILEUS VIRGINIANUS*)

On August 18, 1948, the diagnostic laboratory at Cornell University found evidence of rabies in a white-tailed deer (*Odocoileus virginianus*) taken in the Town of Brookfield, Madison County, New York. This has been the only case recorded in deer since the rabies outbreak began in 1946. Past records indicate it to be very rare; sight records are unreliable.

The animal was seen in a pasture harassing a herd of cows and when approached by a farm lad, the deer proceeded to chase him from the field. When destroyed the animal was badly bruised and lacerated about the head from self-inflicted injury caused by ramming and butting. The source of infection is unknown, but infected foxes or dogs are the most likely possibilities.—JOHN E. WILSON, *N. Y. S. Dept. of Conservation.* *Received September 24, 1948.*

REVIEWS

Hatt, Robert T., Josselyn Van Tyne, Laurence C. Stuart, Clifford H. Pope, and Arnold B. Grobman. ISLAND LIFE: A STUDY OF THE LAND VERTEBRATES OF THE ISLANDS OF EASTERN LAKE MICHIGAN. Bulletin No. 27, Cranbrook Institute of Science, Bloomfield Hills, Michigan. Pp. xi + 179, 43 figs., 1 map, frontis., 15 tables. June 30, 1948. Price, $4.00.

This long-awaited volume is a study in animal geography, many phases of which are particularly well presented by insular faunas. It results from investigations carried on jointly by the Cranbrook Institute of Science and the University of Michigan from 1937 to 1944, with eleven persons participating. Work was concentrated largely on 14 islands in the upper waters of Lake Michigan, varying greatly in size, distance from the mainland, and ecologic diversity. The geographic and ecologic distribution of the land vertebrates were studied and attempts made to determine the means by which the islands were populated.

Except for the chapter on *The Birds*, written by Van Tyne, the material was compiled, synthesized, and edited by Hatt, with the several other authors discussing and reviewing the general sections as well as those pertaining to their special fields. Introductory chapters deal with the geological and cultural history of the islands, detailed descriptions of each, and related studies on these islands. Annotated lists of the island fauna, admittedly incomplete, include 30 amphibian, 8 reptile, 152 bird, and 28 mammal species. No conspicuous evidences of differentiation are noted among the mammals. A chapter on *Modification of Habits* mentions changes in ecological distribution among certain mammals—meadow voles overran the forests of Marion Island and woodland deermice were abundant in driftwood on the Beaver Islands. A final chapter on *Factors of Distribution* summarizes the various principles determining the fauna of the islands. An appendix listing the recorded vertebrates by islands, a bibliography of 75 titles, and an index to species and areas studied are useful features.

It seems probable that most of the islands date from the glacial Lake Nipissing stage. Even today the isolation by water is only seasonal, for the red fox, hare, cottontail, and caribou are known (p. 141) to have crossed from the mainland on ice. The faunal variety on the individual islands corresponds more closely to the ecological diversity of the island than to its absolute area. The island fauna as a whole is a diluted version of that on the adjacent mainland; discounting the forms known to have been introduced by man, only about one-fourth of the mainland mammals have reached and established themselves on the islands. Various reasons for the failure of others to do so are discussed. Beach drift is advanced as a means of dispersal for some forms, and the affinities of the fauna indicate the Lower Peninsula of Michigan as their source, though the evidence is sparse. In summary, it is stated (p. 143) that "With so little knowledge of the habits of the fauna, and even less knowl-

edge of palaeogeographic conditions, we can do no more than present our evidence . . . and await more ample data before arriving at any definite conclusion." Man's influence on the islands has been considerable, through trapping, lumbering, and finally agriculture. We read with interest (p. 48) that "Clearly the work of man on South Fox has proven beneficial to the animal life of the island. Buildings, fields, sawdust piles, even driftwood, have been man-wrought shelters greatly increasing the populations of some species if not indeed making their very existence there a possibility."

In format, this book lives up to the high standards we have come to expect of the Cranbrook Press. The paper is of good quality, the type clear, the binding attractive, the photographs well reproduced, and few typographical errors mar the pages. It seems unfortunate that the title on the cover and title page (as above) and on the dust jacket and spine ("Island Life in Lake Michigan") are not in agreement. One might wish for further details concerning the presence of the domestic rabbit, *Oryctolagus cuniculus*, on South Manitou Island (p. 132). Mention of the "winter lethargy" of the porcupine (p. 141) seems ill-advised, and a digression concerning the red squirrel on Isle Royale which "has become a distinct species" (p. 125) is certainly an exaggeration. An attempt has been made throughout the book, with only a few inconsistencies, to capitalize all vernacular names. All records are distinguished as by sight, sound, sign, report, actual specimen, or of uncertain status, and introduced forms are so indicated, which is most helpful. The book increases our knowledge of animal distribution in Michigan and should prove most useful to biologists visiting these islands, and it serves as a solid foundation for future work which it is hoped will be carried out.—RICHARD H. MANVILLE.

Show, S. B., A. G. Brenneis, F. P. Cronemiller, R. L. Deering, Ivan Sack, and D. M. Traugh. WILDLIFE MANAGEMENT HANDBOOK FOR FOREST OFFICERS—REGION 5. Oakland, Calif. Forest Service, U. S. Dept. Agr., pp. 243, figs. 8. 1947. Looseleaf.

As the title implies, this compilation of pertinent information and procedures is primarily for Forest Service field personnel in the western region of the United States. It covers the best known management measures applicable to mammals, birds, and fishes in the National forests of the west.

The principles and methods of management are outlined in two parts, under the headings "Game Management Section" and "Fish Management Section." These include controls in management of such items as habitat, inherent qualities of species and populations, and management methods. The handbook gives specific suggestions on legal control of harvest, control of predators and disease, and restoring populations of introduced and exotic species, as well as special treatment for vanishing and rare species. It is encouraging to know that the needs of the latter are receiving some attention, as most groups interested in management consider only game species abundant enough to permit hunting.

Although all forms of wildlife are considered, the mammals of the western forests are given more emphasis than are the birds and fishes. The problems of forest officers are centered around big game and predatory mammals. Multiple and sustained use of government forest and range lands are followed as sound basic policies. The ecological approach to a balanced environment has kept consideration of the predator-prey relationships on an open-minded plane. Mammalogists interested in maintaining balanced populations of all native species can take encouragement that such a broad and reasonable approach is becoming the rule among agencies handling large blocks of public land. The Forest Service should be given positive backing in its program of wildlife management.

The extensive Appendix of eleven parts is of particular value to field officers as it contains a summary analysis of requirements and qualities of important game vertebrates. Twenty-eight species of mammals are included, divided into these groups: big game, small game, fur bearers, and predators. Introduced and exotic species of mammals, from the feral house cat and opossum to the wild boar and American elk, are included. The game birds and fishes are treated in much the same way. Other units in the Appendix are equally useful, giving information on meaning of terms; projects, structures, and devices; census methods; and

materials to collect for study and identification. The authors have added information and suggestions on co-operation with sportsmen's clubs, land owners, and State and Federal governments. Instructions are included on legal authority of forest officers and on methods of making management plans for forest fish and game.

This handbook is well indexed. It is small enough to carry in a field-coat pocket. Due to its looseleaf binding, notes and new material may be added with ease. One part dealing with reference books, bulletins, and library facilities, as well as a list of wildlife authorities, should be valuable to many besides forest officers. It is unfortunate that the Forest Service has not prepared as suitable handbooks for the other regions.—WARREN W. CHASE.

RECENT LITERATURE

(Conducted by Gerrit S. Miller, Jr., Remington Kellogg, and Emma M. Charters)

[Reprints of this section may be purchased from the Corresponding Secretary]

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NOTICE OF ANNUAL MEETING

Regular sessions of the Twenty-ninth Annual Meeting will be in the U. S. National Museum, Washington, June 15–17, 1949. Headquarters will be at the Hotel Washington. The Board of Directors will meet on the evening of June 14. The local Committee has an interesting program in store. The American Society of Ichthyologists and Herpetologists will meet at the same place, June 18–21, 1949.

Titles for papers must be submitted *before May 26*. Send titles for American Society of Mammalogists to *Dr. D. F. Hoffmeister, Museum of Natural History, Univ. of Ill., Urbana, Ill.*

DATE OF ISSUE OF PREVIOUS NUMBER

Vol. 30, No. 1, Journal of Mammalogy, mailed **February, 14, 1949**